

CORNELL UNIVERSITY OFFICIAL PUBLICATION

VOLUME X

NUMBER 6

ANNOUNCEMENT OF THE SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS 1919-1920

FEBRUARY 15, 1919
PUBLISHED BY CORNELL UNIVERSITY
ITHACA NEW YORK

This announcement is intended to give detailed information to prospective students in the Sibley College of Mechanical Engineering and the Mechanic Arts of Cornell University.

For general information concerning the University and its various colleges, the requirements for admission, etc., the General Circular of Information should be consulted. This and the other publications of Cornell University are listed on the last page of the cover of this pamphlet. Any one of the informational publications there mentioned will be sent gratis and post-free on application to The Secretary of Cornell University, Ithaca, N. Y.

CALENDAR

First Term 1919-1920

Sept. 19,	Friday,	Entrance examinations begin.
Sept. 24,	Wednesday,	Entrance examinations end
Sept. 29 & 30,	Mon. & Tues.,	Registration of new students.
Oct. 1,	Wednesday,	Registration of matriculated students.
Oct. 2,	Thursday,	Instruction begins. The President's annual address to the students, 12 P. M.
Oct. 4,	Saturday,	Registration of graduate students.
Oct. 21,	Tuesday,	Last day for payment of tuition.
Nov. —,	Thursday,	Thanksgiving recess of one day.
Dec. 20,	Saturday,	Instruction ends at 1 P. M.
Jan. 5,	Monday,	Instruction resumed at 1 P. M. } Christmas Recess.
Jan. 11,	Sunday,	Founder's Day.
Jan. 31,	Saturday,	Instruction ends at 6 P. M.
Feb. 2,	Monday,	Final examinations begin.
Feb. 11,	Wednesday,	Final examinations end

Second Term 1919-1920

Feb. 14,	Saturday,	Registration of undergraduates.
Feb. 16,	Monday,	Registration of graduate students.
Feb. 16,	Monday,	Instruction resumed at 8 A. M.
Mar. 5,	Friday,	Last day for payment of tuition.
Mar. 31,	Wednesday,	Instruction ends at 1 P. M. } Spring Recess.
Apr. 6,	Tuesday,	Instruction resumed at 1 P.M. }
May 22,	Saturday,	Navy Day.
June 9,	Wednesday,	Final examinations begin.
June 17,	Thursday,	Final examinations end.
June 23,	Wednesday,	Commencement.

INDEX

	Page		Page
Admission	15	Instruction:	24-46
Preparation for	14	General outline of	20
Buildings	8	Purposes of	7
Cornell University, Colleges of	3	Subjects	32
Courses of Instruction	24	Laboratories	9
Departments of Sibley College	20	Limited Students	17
Elective Subjects	31	Prizes	12
Entrance:		Requirements for admission	16
Examinations	15	Research	11-22-42
Methods	15	Scholarships	12
Requirements	14-19	Special Students	18
Subjects	15-16	Study, courses of	24
Equipment	8	Subjects:	
Faculty of Sibley College	5	in College of Arts and Sciences	32
Fellowships, graduate	12	in Sibley College	35
Graduate Work	18	entrance	15
		elective	31

CORNELL UNIVERSITY

Cornell University was incorporated under the laws of the State of New York on April 27, 1865, and was opened on October 7, 1868.

By the Morrill Land Grant Act (July 2, 1862), Congress granted to the several states certain public lands from the sale of which should be established at least one institution of higher learning in each state. By the act of April 27, 1865, the Legislature of New York State granted its share of these lands to the foundation of Cornell University.

To this combination of federal and state beneficence, Ezra Cornell added the resources of his own private fortune, and through his effort the University was established.

With the exception of the New York State College of Agriculture and of Veterinary Medicine, which were founded and are supported almost entirely by the New York State Legislature with the aid of the federal government, the University in the main is supported by the income from the original endowment and from the funds donated subsequently by various benefactors.

The University is at Ithaca, New York, a city of sixteen thousand inhabitants, located at the south end of Cayuga Lake. The University Campus, lying high on the slope of the hills east of the town, commands a view of the western hills and of the valley and lake, which is of exceptional beauty.

The University, with an instructing staff numbering about eight hundred, and a student enrollment under normal conditions of more than five thousand, is composed of the Graduate School (degrees A.M., M.M.E., Ph.D., etc), and the following colleges:

The College of Arts and Sciences (degree A.B., B.Chem.),

The College of Law (degree LL.B.),

The Medical College (degree M.D.),

The New York State Veterinary College (degree D.V.M.),

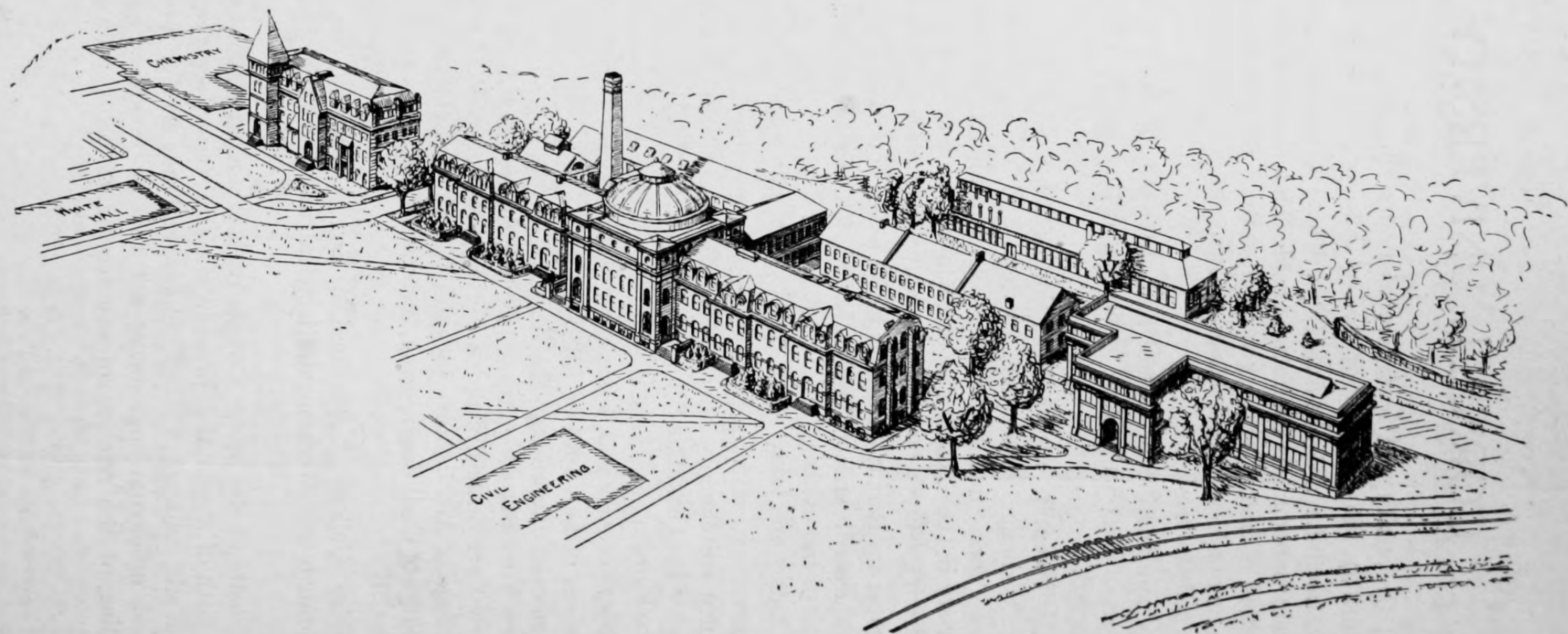
The New York State College of Agriculture (degree B.S.),

The College of Architecture (degrees B.Arch. and B.S. in Arch.),

The College of Civil Engineering, including Hydraulics and Sanitary Engineering (degree C.E.).

The Sibley College of Mechanical Engineering and the Mechanic Arts, including branches of Mechanical, Electrical, and Industrial Engineering (degree M.E.).

The students of the Sibley College of Mechanical Engineering, constituting nearly one-fifth of the total number in the University, are thus associated with the faculties and students of other colleges, and may receive intellectual stimulus in many fields other than engineering, and thus be broadened and given a clearer understanding of the relation of engineering to other human activities and interests.



Buildings of Sibley College

SIBLEY COLLEGE OF MECHANICAL ENGINEERING AND THE MECHANIC ARTS

FACULTY

Jacob Gould Schurman, A.M., D.Sc., LL.D., President.
Albert William Smith, B.M.E., M.M.E., Dean of the Faculty and Professor of Power Engineering.
Dexter Simpson Kimball, A.B., M.E., Professor of Machine Design and Industrial Engineering.
George Robert McDermott, Professor of Structural Design.
Herman Diederichs, M.E., Professor of Experimental Engineering.
Alexander Gray, B.S. in C.E., M.S. in E.E., Whitworth Scholar, Professor of Electrical Engineering.
William Nichols Barnard, M.E., Professor of Power Engineering.
Vladimir Karapetoff, C.E., M.M.E., Professor of Electrical Engineering.
Edgar Harper Wood, M.E., M.M.E., Professor of Mechanics of Engineering.
Calvin Dodge Albert, M.E., Professor of Machine Design.
Albert Edward Wells, Professor of Machine Construction.
Frank Oakes Ellenwood, A.B., Professor of Power Engineering.
Will Miller Sawdon, B.S. in M.E., M.M.E., Professor of Experimental Engineering, Assigned to Engineering Research.
George Burr Upton, M.E., M.M.E., Assistant Professor of Experimental Engineering.
Seymour Stanton Garrett, C.E., Assistant Professor of Mechanics of Engineering.
Victor Raymond Gage, M.E., M.M.E., Assistant Professor of Experimental Engineering.
Robertson Matthews, M.E., Assistant Professor of Power Engineering.
Clarence Walter Ham, B.M.E., M.E., Assistant Professor of Machine Design.
Myron A. Lee, M.E., M.M.E., Assistant Professor of Machine Design.
John George Pertsch, jr., M.E., Assistant Professor of Electrical Engineering.
Frederick George Switzer, M.E., M.M.E., Assistant Professor of Hydraulics.
William Cyrus Ballard, jr., M.E., Assistant Professor of Electrical Engineering.
Fred Stillman Rogers, B.S., M.E., Assistant Professor of Machine Design.
Clarence Ellsworth Townsend, M.E., Assistant Professor of Machine Design.
Walter Rodney Cornell, C.E., B.S., Instructor in Mechanics of Engineering.
Robert Franklin Chamberlain, M.E., Instructor in Electrical Engineering.
Enoch Francis Garner, M.E., Instructor in Machine Design.
Homer James Hotchkiss, A.M., M.M.E., Instructor in Mechanics of Engineering.
Harold Charles Perkins, M.E., Instructor in Mechanics of Engineering.
William Emerson Mordoff, M.E., Instructor in Experimental Engineering.
George Francis Bason, B.E., M.E., Instructor in Electrical Engineering.
Clinton Russell Tobey, Instructor in Machine Design.
Shurley Russell Irish, Instructor in Machine Design.

Assistants

James Eugene Vanderhoef, Foreman of Foundry.
Walter Liston Head, Foreman of Forge Shop.
Leroy Hooper, Foreman of Pattern Shop.
Paul Wellenkamp, Assistant in Machine Shop.
Howard Stanley Bush, Assistant in Pattern Shop.
Charles Albert Brooks, Assistant in Forge Shop.
Charles E. Patterson, Assistant in Foundry.
William Frederick Head, Assistant in Forge Shop.
David Bush Green, Assistant in Machine Shop.

George Washington Race, Mechanician in Experimental Engineering.
Edward Warren Gregory, Mechanician in Experimental Engineering.
George Alfred Culligan, Mechanician in Electrical Engineering.
Alfred William Neigh, Engineer.

Margaret Isabelle Colquhoun, Clerk in Experimental Engineering
Maude Newman, Clerk of Records.
Lena Gertrude Marsh, Librarian of Sibley College.
Mary Clemence Price, Secretary to the Dean of Sibley College.

PURPOSES OF INSTRUCTION

Sibley College is organized, primarily, to teach the fundamental principles, theoretical and practical, that underlie the various branches of mechanical and electrical engineering. In addition to this there is included such work in pure and applied economics as is needed by the engineer of the present time. In the senior year students may take any one of the following options:

- A. **Electrical Engineering.**
- B. **Heat-Power Engineering.** Steam Engineering or Internal Combustion Engineering.
- C. **Structural and Plant Engineering.**
- D. **Ship Design and Construction.**
- E. **Industrial Engineering.**

Since the work in any one of these options includes only a portion of the time of one academic year out of four, it follows that specialization cannot be carried very far; in fact the faculty of Sibley College holds the opinion that the duty of a technical school to its undergraduates is to train them thoroughly in fundamental subjects and that the four-year course is none too long for this purpose; hence the pressure to introduce narrow specialization early in the course has always been firmly resisted.

It is well recognized that theoretical instruction must be supplemented by experience in practice and by contact with life before one can attain his greatest usefulness in the profession; hence, in Sibley College, an effort is made to bring the student into contact with teachers who are closely in touch with commercial engineering practice to the end that he may thus become familiar with problems encountered in modern engineering and with commercial methods of solving them. It is hoped in this way to shorten somewhat the period of adjustment for the graduate when he begins actual engineering work.

The success of an engineer has come more and more to depend upon his ability to meet men of education and culture on equal terms. Since the work in the regular four-year course in this college is almost wholly technical, it is preferable that the student before entering the College should have a thorough general education, and, if possible, the training of a liberal college course. Those who have not had this broader education should, if possible, devote one or two years to subjects taught in the College of Arts and Sciences. A **five-year course** for Sibley students, including the equivalent of one year of this broader training, is outlined on pages 29 and 30; and a **six-year course** leading to the degrees of A.B. and M.E. is described on page 31. The entrance requirements for these courses demand less mathematical preparation than is specified for the four-year engineering course.

In addition to the prescribed courses in Sibley College those students who have the necessary time available may elect, with the permission of their class adviser, any course in any college of the University, provided they have had the required preparation for the work.

OPPORTUNITIES FOR EMPLOYMENT AFTER GRADUATION

Mechanical Engineering underlies nearly all branches of the industries: its province includes the design, construction, operation and testing of steam engines, steam turbines, boilers and power plants auxiliaries, gas and oil engines with their auxiliaries, hydraulic machinery, pumping engines, railway equipment, compressed air machinery, ice making and refrigerating machinery, equipment for heating and ventilation, machine tools, mill equipment and transmission machinery. The work of the mechanical engineer includes the planning of power plants and factories, the selection and installation of their equipment, the development of the systems of operation and of manufacturing processes and the organization and administration of industries. **Electrical Engineering** includes the design, construction, operation and testing of electrical equipment used for the generation, transmission, and utilization of electrical energy.

From the foregoing very brief outline of some of the fields covered by the branches of engineering for which the students of Sibley College are fundamentally prepared, it is seen that the opportunities for the graduates to secure employment are extremely broad. The graduates, after gaining requisite experience in practice, usually occupy such positions as designers, supervisors of construction, inspectors, testers, research engineers, superintendents of departments, works managers, efficiency engineers, specialists in welfare work and in labor problems, consulting engineers, insurance investigators, commercial representatives, engineering salesmen, educators, and managers and presidents of commercial organizations.

There has always been a dearth of men fitted to fill the higher positions in the engineering and business fields; and the salary and position that the graduate will eventually obtain depends not only on his engineering training but on his inherent ability, industry, initiative, capacity to recognize and seize opportunities as they arise, and on his other personal qualities. The young man who has just graduated from Sibley College has little difficulty in securing immediate employment with salary sufficient for self-support, and if he eventually shows the proper qualifications he may rise to the highest positions attainable in engineering and business fields.

BUILDINGS AND EQUIPMENT OF SIBLEY COLLEGE

The Sibley College of Mechanical Engineering and the Mechanic Arts receives its name from the late Hiram Sibley of Rochester, who between the years 1870 and 1887, gave \$180,000 towards its endowment and equipment. Mr. Hiram W. Sibley has added more than \$150,000 for later constructions and equipment. The Sibley buildings are situated at the north end of the Campus, and stand upon ground leased from the University for the purposes of the College, under an agreement with the late Hiram Sibley. There are six large buildings in the group.

The main building is three hundred and seventy feet long, fifty feet in width, and three stories in height. It contains the reading room and reference library, drawing rooms, lecture rooms, offices, class rooms, and a large and well-lighted auditorium.

Franklin Hall is occupied on its first two floors by the Department of Electrical Engineering, which in addition uses temporarily a portion of Rand Hall.

The Department of Experimental Engineering occupies two two-story buildings, each about one hundred and fifty feet long by forty feet wide, besides a boiler plant thirty by forty feet, a refrigeration laboratory thirty by forty feet, and the east basement of the main building.

Rand Hall has recently been added to the Sibley College group (at a cost of \$60,000) through the generosity of Mrs. Florence O. R. Lang. This building is a memorial to Jasper R. Rand, Addison C. Rand, and Jasper R. Rand, jr., the father, uncle, and brother of the donor. It is a three-story building, the main portion of which is one hundred and seventy feet long and fifty feet wide; it contains the machine shop and pattern shop, and a portion is used temporarily for the electrical laboratories.

The foundry and forge shops occupy a one-story building one hundred and eighty feet long and forty feet wide.

MECHANICAL LABORATORIES

The instruction in the Department of Experimental Engineering is given in several separate laboratories, each of which is thoroughly equipped with the machines, apparatus, and instruments necessary for instruction in research.

The Materials Testing Laboratory. This laboratory is equipped for tension and compression tests with an Olsen 300,000 pound machine, a Riehle 100,000 pound machine, a 200,000 pound Emery hydraulic machine, together with several other machines varying in capacity from 10,000 to 100,000 pounds. For transverse tests there is a Riehle machine of 200,000 pounds capacity and a Fairbanks machine of 10,000 pounds capacity. There are two Thurston autographic torsion machines, one Olsen torsion machine of 200,000 inch-pounds capacity, and two Upton-Lewis fatigue testing machines. The equipment includes extensometers, a cathetometer, gas furnaces, tempering baths, and all other apparatus required for the determination of the physical qualities of engineering materials under tensile, compressive, transverse, and torsional stress, and under different kinds of heat treatment.

The Steam Laboratory. In this laboratory there is a 150 H. P. triple expansion Allis-Corliss engine so fitted up that it may be operated as a simple, compound, or triple expansion engine, condensing or non-condensing. There are also several smaller engines, including a Russell, a Harris-Corliss, a Payne, a Troy, a Wickes Bros. automatic engine, and a three-cylinder, compound, Laidlaw-Dunn-Gordon steam pump capable of delivering 300 gallons of water per minute against a pressure of 300 lbs. per square inch. There are three surface condensers which may be connected with these engines as desired. There is a 35 kw. horizontal Curtis turbine and a 15 kw. De Laval turbine which drive electric generators and may be run condensing or non-condensing.

A two-stage steam-driven Ingersoll-Rand compressor and three air-brake pumps of different types, together with meters, nozzles, and other instruments, are used for routine tests. This part of the laboratory also has several fans that can be arranged and equipped for testing.

The apparatus and instruments used for engine testing comprise about 80 indicators of different types, about 75 steam gauges, a number of calorimeters for the determination of the quality of steam, speed counters, tachometers, planimeters, etc., besides a number of dynamometers of various kinds.

The boiler section of this laboratory has one 150 H. P. Babcock & Wilcox water-tube boiler of the marine type, and one 100 H. P. Babcock & Wilcox water-tube boiler of the standard type, both of which are fitted with internal superheaters. There is also one 80 H. P. Heine water-tube boiler and one 25 H. P. Roberts safety boiler connected with a Foster independent superheater. The auxiliary apparatus consists of a Cochrane open heater, a Wainwright closed heater, steam pumps, traps, injectors, etc. A full set of scales, measuring tanks, gauges, flue gas apparatus, separating and throttling calorimeters, pyrometers, etc., complete the boiler equipment.

The Gas Engine Laboratory. The equipment includes an 8 H. P. Westinghouse gas engine, an 8 H. P. Olds gasoline engine, an 8 H. P. Fairbanks gasoline engine, a 6 H. P. "Ingeco" oil engine, a 6 H. P. Hornsby-Akroyd oil engine, a 15 H. P. Hornsby-Akroyd oil engine, a 16 H. P. Acme gas engine run on producer gas from a 15 H. P. suction gas-producer, and a 30 H. P. three-cylinder Westinghouse gas engine with gas producer and a 45 H. P. McIntosh & Seymour Diesel engine direct connected to a D. C. generator. Hot air engines are represented by a Rider and an Ericsson engine. This engine equipment is chosen to give as great a variety as possible in the fuels used, types of governing, etc.

The supply of testing instruments includes several outside spring indicators, optical indicators, and a manograph. For temperature measurements there are available high-reading thermometers and pyrometers of the expansion and electrical types.

The Hydraulic Laboratory. This laboratory contains the following machines and apparatus: a 6-inch single-stage De Laval centrifugal pump; a 2½-inch two-stage Worthington centrifugal pump; 12-inch Doble water wheel; a 10-inch Trump turbine; several Pelton wheels and hydraulic rams; sets of weir boxes with various types of weirs and nozzles for the determination of coefficients of discharge; various types of water meters and other apparatus for measuring the flow of water, such as Pitot tubes, Venturi meters, current meters, etc.

The Oil Testing Laboratory. This laboratory contains a Cornell oil-testing machine, a Thurston standard railway-testing machine, and several smaller Thurston machines. The rest of the equipment consists of several viscosimeters of different types, together with the necessary hydrometers and thermometers.

The Refrigeration Laboratory. For the study of refrigeration the mechanical laboratory possesses a 2-ton York absorption machine and a very complete York refrigerating compression plant having a capacity of 15 tons of ice.

The Cement Laboratory. This laboratory not only contains the ordinary apparatus for the testing of cement and concrete, but in addition is equipped with crushing and grinding machinery and a small vertical kiln for making investigations on the manufacture of cement from raw material.

The Fuel Testing Laboratory. This laboratory contains a complete equipment of fuel calorimeters and other apparatus needed for the determination of the composition and calorific value of fuel, whether gaseous, liquid, or solid.

THE ELECTRICAL EQUIPMENT

The Lecture Equipment. The lecture room is exceptionally well provided with display apparatus and with apparatus especially designed for demonstration

purposes. All types of electrical machinery may be operated on the lecture table and a 60,000 volt transformer is provided for insulator testing.

The Dynamo Laboratories. These laboratories are provided with a great variety of standard and special machines for both direct and alternating current work, along with the necessary meters and control equipment. Among the special pieces of equipment are a street car truck with motors and also a complete outfit for exhibiting in actual operation the multiple unit system of electric car control.

The Standardizing Laboratory. This laboratory is equipped with the necessary potentiometers, galvanometers and standards for the calibration of instruments, and the testing of materials used in electrical work. There is also a G.E. oscillograph for work on wave form.

The Wireless Laboratory. This laboratory has a 5-kilowatt, 500 cycle sending set, also a 2-kilowatt, 60 cycle set, both being equipped with rotary and also with quenched spark gaps. The receiving equipment includes crystal, audion and other detectors. The aerial is about 500 feet long and, by means of some of the new supersensitive apparatus, a receiving range of 5000 miles is obtained.

The power for the various laboratories is obtained from the University Hydro-electric Plant, which contains large three-phase alternators, direct-driven by both impulse and reaction water-wheels. This plant is complete in every respect and is used for inspection.

ENGINEERING RESEARCH EQUIPMENT

The Research Division of the Department of Experimental Engineering has all the equipment and resources of the various departments of Sibley College available for use in connection with its investigations. (See announcements of these departments.) It is also possible, in most instances, to arrange to use the engineering and scientific equipment of the other Colleges of the University. This division has some special equipment including a belt and pulley testing machine and a 150 H. P. electric dynamometer for testing automobile motors.

WORK SHOPS

The foundry occupies floor space of about 4,800 square feet, and has an equipment for the production of iron and composition castings. The methods of producing duplicate work are demonstrated by moulding machines of different types selected to illustrate the production of castings of various kinds at lowest labor cost.

The forge shop has the usual equipment of standard forges and small tools, as well as a modern drop-forge plant. Forging by the drop-hammer method, and power press work are demonstrated and discussed.

The pattern shop occupies the top floor of Rand Hall with floor space of 8,440 square feet. The work given the students in this department includes the use of hand and power operated tools under instructors who are skilled in the trade of pattern making.

The machine shop is located on the ground floor of Rand Hall with the same floor area as the pattern shop. It is equipped with an electric traveling crane and representative modern machine tools selected with a view of demonstrating manufacturing methods. A part of the work-shop equipment is installed to

illustrate the latest practice in production with specialized labor-saving machinery. The students are not expected to become skilled operators of the machines of this class, but to acquire a general knowledge of their possibilities in the kinds of work to which they are adapted. The equipment is arranged in groups, each under the charge of an instructor who has made a special study of the machinery in his group.

ENGINEERING LIBRARY

The Library of Sibley College, which is a branch of the University Library, contains an excellent equipment of reference books and periodical literature relating to the fields of engineering taught in Sibley College and to the allied branches of learning. In addition to this library the student has access to the University Library and to the special libraries of the other Colleges and Departments of the University.

SCHOLARSHIPS, PRIZES, AND LOANS

A special pamphlet on prizes may be secured from the Secretary of the University. A description of the scholarships open to entering freshmen in all colleges is given in the General Circular of Information. Regarding Graduate Scholarships, Fellowships, etc., see the Announcement of the Graduate School.

State Tuition Scholarships. (Awarded by New York State). Under the law of the State of New York the Commissioner of Education is empowered to award annually a number of free scholarships in Cornell University equal to the number of Assembly districts in the State of New York. Each scholarship entitles the holder to free tuition for four years beginning in the September immediately following the award of the scholarship.

All scholarship holders must satisfy the regular requirements for admission to one of the colleges of the University.*

State Cash Scholarships. (Awarded by New York State.) Under the law of the State of New York (Chapter 292, Laws of 1913), State Scholarships have been established in the several counties of the State, to be maintained by the State as provided by law. Five such scholarships are to be awarded each county annually for each assembly district therein. Each such scholarship will entitle the holder thereof to the sum of one hundred dollars for each year of his attendance upon an approved college in this State during a period of four years.*

University Undergraduate Scholarships. (Awarded by the University.) Eighteen University Undergraduate Scholarships, each continuing for two years and of an annual value of \$200, are offered each year to members of the incoming freshman class. The award is made on the basis of a special competitive examination held in Ithaca in September between the period of entrance examinations and the opening of the University. Every candidate for such a scholarship must have satisfied the entrance requirements for one of the colleges of the University. Holders of New York State Scholarships are eligible for University Undergraduate Scholarships. The University Undergraduate Scholarships will be awarded on the basis of examinations in three of the eight following subjects:

*For particulars in regard to the awarding of State Scholarships, application should be made to the Commissioner of Education, Albany, N. Y.

English, Greek, Latin, French, German, Spanish, Elementary Mathematics, Advanced Mathematics. Certain combinations of these subjects are specified.*

The Buffalo Alumni Association Scholarship of an annual value of \$200 is offered to students who are residents of Erie or Niagara County, New York.*

The Student Fund of the Cornell Club of Rochester provides for a loan of an annual value of \$200.*

Graduate Fellowships. There are three fellowships in Mechanical and Electrical Engineering, with an annual value of \$400 each. (See Announcement of the Graduate School.)

The attention of **Sibley students** is directed particularly to the following paragraphs:

The Frank William Padgham Scholarship. This scholarship, founded in 1892 by Amos Padgham of Syracuse, New York, in memory of his son, Frank William Padgham, a graduate of Sibley College of the class of 1888, entitles the holder to free tuition and fees in the regular course in Sibley College of Mechanical Engineering. It cannot be held in connection with a New York State Scholarship. The Frank William Padgham Scholarship will be awarded to the candidate who has had his preparatory education wholly or in part in the public schools of Syracuse, New York, and who, having been admitted to the regular course in Sibley College, shall pass the best examination in a competitive examination on the following studies selected from those that may be offered for admission to Sibley College: 1. solid geometry; advanced algebra; plane trigonometry; 2. third year German; 3. third year French; 4. English. Of these subjects the candidate must take three, including mathematics. The examination for the Padgham Scholarship is held at the same time as the University Undergraduate Scholarship examinations; it is, however, a special examination and the candidate must declare his intention to enter the Padgham Scholarship examination and state his qualifications therefor to the Registrar, who will issue the usual permit to enter the examination. In case no one qualifies for this scholarship in the foregoing manner, the Faculty of Sibley College may, with certain restrictions, recommend the awarding of the scholarship to some worthy applicant, preferably one from Syracuse. Upon request, detailed information regarding the examinations and the awarding of this scholarship will be furnished by the Dean of Sibley College or by the Registrar of Cornell University.

Fred Lewis Wilson Scholarship. The sum of approximately \$4000 was bequeathed to Cornell University by Mrs. Mary Northup Wilson to found and perpetuate one or more scholarships in honor of her son, Fred Lewis Wilson, who was graduated from Sibley College of Mechanical Engineering with the class of 1892.

These scholarships will be awarded, for a period of not more than two years each, to undergraduates who have been at least one year in the University, under the following conditions:

"Scholarships arising out of this bequest shall be awarded by a committee consisting of the President of the University and the Director of Sibley College, and one other person chosen by them; and in making such awards the following attributes shall be given the weight indicated; scholarship, evidenced by written

*For details see the General Circular of Information.

examination, 30 per cent; character, in the broadest sense, 30 per cent; probable usefulness in the world at large, 30 per cent; proficiency in mechanic arts, 10 per cent; it being understood that these scholarships are intended to assist such students as are in need of financial aid to complete their courses."

Sibley Prizes in Mechanic Arts. Under the gift of the late Hiram Sibley, made in 1884, the sum of one hundred dollars will be awarded annually in five prizes to juniors and seniors in Sibley College who have received the highest marks in scholarship in at least three full terms of work required in the Sibley College course and done in that college. The prizes are \$30, \$25, \$20, \$15 and \$10.

The Fuertes Memorial Prizes in Public Speaking, founded by Charles H. Baker, C.E., '86, consisting of \$125, \$35, and \$20, respectively, are awarded annually to those members of the junior and senior classes in the Colleges of Engineering and Architecture, who may be selected after competitive trial in public speaking. The orations delivered in competition for these prizes are to be original compositions on technical subjects and must be argumentative in character. In making the awards both the character of the argument and the manner of delivery will be considered.

F. W. Guiteau Student Loan Fund. Through the generosity of the late Mr. Frederick W. Guiteau and his sister, the late Mrs. Nancy G. Howe, both of Irvington-on-Hudson, New York, a fund, known as the F. W. Guiteau Student Loan Fund, has been established in Cornell University, the income from which, amounting to about \$14,000 annually, is to be used "in advancing and assisting needful, worthy young men in pursuing their studies in said University." There is also a small separate fund available for women students.

The benefits of these funds are open to young men and young women who have been in attendance at Cornell University for at least one year but preference is given to seniors and juniors. Account is taken of the applicant's character, scholastic record, and need of financial assistance. Loans are made primarily to cover tuition fees.

***The Wurts Loan Fund,** the gift of Alexander Jay Wurts, in memory of his mother Laura Jay Wurts, was founded in 1912 to assist needy students of the two upper classes in Sibley College. Upon the recommendation of the Dean of Sibley College, loans from the income from this fund may be awarded by the Faculty of Sibley College, with the approval of the Treasurer, to one or more students each year.

PREPARATION FOR ADMISSION

As the instruction in Sibley College is almost entirely of a scientific or engineering character, and as, at best, the student in the four-year course has only very limited opportunities for instruction along broader lines, it is desirable that the training for entrance to that course should be as liberal as possible with stress on subjects like language and history, and with physics and chemistry deferred until after entering the University.

While three years of any one, or two years of any two, of the foreign languages listed on page 15 will be accepted by this college as satisfying the language requirement for admission, prospective students are strongly advised to study German

*For information regarding the other loan funds and the opportunities for self-support see the General Circular of Information or the pamphlet on Self-Help.

and French, not only for their cultural value but for their engineering literature. It is of advantage for those entering the engineering courses to have had some instruction in free-hand sketching.

Students who have had some engineering experience usually gain more than others from the courses of Sibley College; hence it is recommended that prospective students spend at least one summer vacation in touch with some kind of engineering work.

As already mentioned, it is desirable for the student to obtain if possible, the training of a liberal college course before entering Sibley College, and those who have not had this broader education are recommended to take either the five-year course or the six-year course, if they can afford the additional time and expense involved.

ADMISSION AND CLASSIFICATION

Sibley College of Mechanical Engineering and the Mechanic Arts offers work to the following five classes of students:

- 1. Regular students in Regular Undergraduate Courses relating to mechanical, electrical, and industrial engineering and leading to the degree of Mechanical Engineer. (See page 16.)
- 2. Limited students in Regular Undergraduate Courses. (See page 17.)
- 3. Regular students entering Regular Undergraduate Courses with advanced standing from other colleges. (See page 17.)
- 4. Special students not pursuing a Regular Undergraduate Course. (See page 18.)
- 5. Graduate students. (See page 18.)

For a six-year course leading to the degrees of Bachelor of Arts and of Mechanical Engineer see page 31.

List of Subjects that may be Offered for Entrance

The following are the lists of approved subjects from which the entrance credits must be made up in combinations specified on pages 16 and 17 for each class of students. A total of 15 units from Groups a and b is required for all courses.

The term "Unit" means the equivalent of five prepared recitations per week for one school year in a subject, or 120 sixty-minute hours. Two hours of laboratory work are considered equivalent to one hour of prepared recitation. See the General Circular of Information for detailed information.

Group a. Required of all entering students

Subject	Units
English No. 1.	1 1/2
English No. 2.	1 1/2
History*	1
Algebra, Elementary.	1
Geometry, Plane.	1
Foreign Language†.	3
Total.	9

*This may be Ancient History, Modern History, American History and Civics, or English History. Any one of them may count one-half or one unit. A total of one unit must be offered; any excess may count as an elective in Group b.

†This may be two units each in two foreign languages, in which case the fourth unit may count as an elective in Group b. The languages offered may be French, German, Spanish, Italian, Greek, or Latin.

Group b. List of elective units from which six must be chosen, unless excess history or foreign language, or both, are offered under Group a. In that case the subjects offered from Group b will have to total six units with the excess units of Group a.

The subjects offered from Group b determine directly the length of time, whether four years or five years, or some intermediate period, that must be spent in study for the degree.

Subject	Units	
Algebra, Intermediate	$\frac{1}{2}$	} Advanced Mathematics.
Algebra, Advanced	$\frac{1}{2}$	
Geometry, Solid	$\frac{1}{2}$	
Trigonometry, Plane	$\frac{1}{2}$	
Trigonometry, Spherical	$\frac{1}{2}$	
Physics	I	
Chemistry	I	
Physical Geography	$\frac{1}{2}$ or I	
Biology*	I	
Botany*	$\frac{1}{2}$ or I	
Zoology*	$\frac{1}{2}$ or I	
Bookkeeping	$\frac{1}{2}$ or I	
Drawing†	$\frac{1}{2}$ or I	
Manual Training†	I	
Any other High School subject.	$\frac{1}{2}$ or I	

Methods of Obtaining Entrance Credit

All correspondence concerning admission to Sibley College should be addressed to the Registrar of Cornell University, Ithaca, N. Y., who will forward the proper application blanks upon request. All credentials relating to admission of new students must be in the hands of the registrar before September first.

Credit for entrance subjects may be secured in the following ways:

- 1. By passing the required Cornell University Entrance Examinations held in September in Ithaca and New York City, and in January in Ithaca.
- 2. By passing the College Entrance Examination Board Examinations held in June in various places. (Address the Secretary of the College Entrance Examination Board, 431 West 117th St., New York City.)
- 3. By passing the Regents' Examinations (for students who have prepared in New York State).
- 4. By presenting an acceptable school certificate.

For the regulations relating to admission at the beginning of the second term see page 18.

1. REQUIREMENTS FOR ADMISSION AS REGULAR STUDENTS IN REGULAR UNDERGRADUATE COURSES

The applicant must be at least sixteen years of age. The time required for graduation depends upon the units offered from Group b, in conjunction with 9 units of Group a, and the following combinations are possible.

- (a) Graduation in 4 years. Regular four-year course (see page 25).

*If an applicant has counted Biology (1) he may not also offer Botany ($\frac{1}{2}$) or Zoology ($\frac{1}{2}$).
†300 actual hours are required for one unit.

Entrance requirements—Group a, 9 units; Group b, all the advanced Mathematics 2 units, and 4 other units. Total from Groups a and b, 15 units.

(b) Graduation in 4 years plus the Summer Session between the Freshman and Sophomore years; or graduation in $4\frac{1}{2}$ years in regular sessions.

Entrance Requirements—Group a, 9 units; Group b, any two of the Advanced Mathematics, 1 unit, and 5 other units. Total from Groups a and b, 15 units.

(c) Graduation in 5 years. Regular five-year course (see page 29).

Entrance Requirements—Group a, 9 units; Group b, any 6 units. Total 15 units.

2. REQUIREMENTS FOR ADMISSION AS LIMITED STUDENTS IN REGULAR UNDERGRADUATE COURSES

[All correspondence concerning the admission of limited students should be addressed to the Dean of Sibley College. All applications for admission must be made on the official blanks provided for the purpose and obtainable from the Dean.]

Men at least twenty-one years of age may be admitted as limited students in mechanical engineering not candidates for a degree, provided they have had sufficient experience in some line of mechanical engineering to show that they are worthy of special consideration, and provided they give evidence of ability to do creditable work in the College, and provided they have neither been previously admitted or refused admission to this, or any other, University as regular students.

They are required to have completed before admission the mathematical preparation of the regular students of either the four-year or the five-year courses (page 15) and may be held for examination in these subjects. There are no special courses for limited students; such students must conform to either the four-year course as outlined on pages 25 to 29, or to the five-year courses (pages 29 and 30), depending on their preparation. Upon fulfilment of all entrance requirements limited students may become regular students and candidates for the degree of M.E. Limited students will not, however, be permitted to make up deficiencies in entrance subjects by attending University instruction in those subjects.

3. ADMISSION FROM OTHER COLLEGES

[All correspondence concerning admission from other colleges should be addressed to the Registrar of Cornell University.]

A student who, having already attended some technical or other institution of collegiate rank, desires to enter the regular course in the Sibley College of Cornell University, should file with the Registrar of Cornell University, on an official blank to be obtained from him, a formal application for admission to Sibley College along with an official certificate from the institution already attended, of his honorable dismissal, his entrance examinations in detail, his terms of attendance and the amount of work that he has completed, and a detailed statement of the courses pursued. He should send also a catalogue of the institution, writing on it his name and marking the entrance requirements that he has satisfied and each subject that he expects to offer. If at the time of admission the student does not satisfy in full the entrance requirements for freshmen (see page 15) he must remove the deficiencies within one year after admission.

4. ADMISSION AS SPECIAL STUDENTS NOT PURSUING A REGULAR UNDERGRADUATE COURSE

[All correspondence concerning admission as Special Students should be addressed to the Dean of Sibley College.]

Men admitted as Special Students must be at least 23 years of age. They must have an extended engineering experience and the theoretical training required for the courses they wish to pursue. It is expected that such students will in general take advanced technical work in regular undergraduate courses together with some research. It is provided that at least one-half the work must be in regular courses and that the regulations regarding standard of scholarship will be in force as for regular students.

Detailed information and advice will be given in each individual case upon statement of work desired.

5. ADMISSION AS GRADUATE STUDENTS

[All correspondence relating to graduate work and graduate fellowships should be addressed to the Dean of the Graduate School.]

In all departments of Sibley College, work is arranged to meet the special needs of graduate students and, in addition, the head of the Department of Experimental Engineering will co-operate in every way to assist the graduate students in mechanical and electrical engineering, and will aid in providing apparatus and other facilities for graduate work. Graduate students register in the Graduate School and not in Sibley College. To be registered as a candidate for the degree of Master of Mechanical Engineering, the student must have satisfied the equivalent of the entrance requirements and of the University subjects specified by Sibley College for the M.E. degree. There are three Fellowships in Mechanical and Electrical Engineering, which have an annual value of \$400 each. For further information regarding admission, registration, fellowships, etc., see Announcement of the Graduate School.

6. ADMISSION AT THE BEGINNING OF THE SECOND TERM

[Certificates and credentials for admission at mid-year should be in the hands of the Registrar not later than January 15.]

Admission at mid-year is possible only under the following conditions:

- (a) A student must meet the regular entrance requirements.
- (b) If a student enters as a freshman without advanced college credit, the time required for his graduation will be 4½ years. See sub-division "b" under Admission as a Regular Student, page 17.
- (c) If entering as a student with advanced standing, with a view to graduating in less than four years, the applicant must have attended an institution of collegiate rank and must secure credit for such university courses as will enable him, by attending during the remainder of the college year and (possibly) during the succeeding Summer Session, to substantially complete the year's work scheduled for the class he wishes to enter.

On application made to the Registrar on or before January 15 in any year special entrance examinations in any of the University entrance subjects may

be arranged for students who must be examined in one or more subjects to complete their requirements for admission at the middle of the year. These special entrance examinations will be held in Ithaca on or about January 25 of each year.

PAYMENTS TO THE UNIVERSITY

[For detailed information regarding payments to the University and the expense of living in Ithaca, see the General Circular of Information.]

Briefly, students entering Sibley College are subject to a matriculation fee of \$5 and to the following payments:

	1st Term	2d Term
University Tuition (\$150 yearly)*	\$ 85	\$65
Sibley Fee (\$25 yearly)†	12.50	12.50
Infirmary Fee (\$6 yearly)	3	3

Each undergraduate student is required to pay a fee of \$2 per term for the use of a locker in the Drill Hall or Gymnasiums. Those taking laboratory courses in other colleges of the University must pay to the Treasurer a fee or deposit for materials used in the work. Payments must be made within 20 days after registration. A graduation fee of \$10 must be paid ten days before graduation. The amount will be refunded should the degree not be conferred. Tuition is free to students holding New York State Tuition Scholarships.

Non-engineering students taking shopwork or laboratory work in Sibley College must pay for such instruction a fee of \$3.50 per record hour. When a student has taken, while in a non-engineering college of the University, part of the work required for the M.E. degree, such student before receiving that degree shall be required to have paid to the University Treasurer such amount as would have been paid if all such work had been taken while registered in Sibley College. The University Treasurer is empowered to adjust the arrears to be paid in irregular cases arising under the foregoing requirements.

A reinstatement fee of twenty-five dollars is charged to every student who has been dropped from the University for delinquency in scholarship or conduct, except for such delinquency in scholarship as is due to ill health or to other reasons beyond the student's control, in which case the fee may be remitted upon recommendation of the Dean of the College in which the student is registered.

A matriculated undergraduate student desiring to register after the close of Registration Day shall first pay a fee of \$5.

A student desiring to file his registration of studies after the date set by his college for filing the same shall pay a fee of \$2.

A student desiring to take an examination or other test for the removal of a term condition (including the making up of a mark of "absent" or "incomplete") shall first pay a fee of \$2 for each examination or other test.

An undergraduate student desiring to continue his University work after having been absent without excuse from his Dean from any class or exercise occurring during the two days immediately preceding or immediately following the Thanksgiving, the Christmas, or the Easter recess, shall pay a fee of \$5 for each day on which an absence occurred.

*All tuition and other fees may be changed by the Trustees to take effect at any time without previous notice.

†Students in the five-year course need pay this fee for but eight terms.

For reasons satisfactory to the Comptroller and the Registrar any of the above mentioned fees (except when assessed for the removal of a condition, E or 41-59 inclusive) may be waived in any individual case upon recommendation of the Dean of the college concerned, if in his judgment the student's failure to comply with the regulation was due to ill health or to other reasons beyond his control.

Nothing in the regulations given above shall be construed as preventing a college from imposing additional academic penalties and regulations.

GENERAL OUTLINE OF INSTRUCTION

The instruction in mathematics, chemistry, physics, and general economics is given in the College of Arts and Sciences. All other regular subjects in the course are of an engineering nature and are given in Sibley College in the following departments: 1. Machine Construction; 2. Machine Design; 3. Mechanics of Engineering; 4. Power Engineering; 5. Experimental Engineering; 6. Electrical Engineering; 7. Industrial Engineering.

The following is a brief outline of the scope and purposes of instruction in the various departments of Sibley College.

1. DEPARTMENT OF MACHINE CONSTRUCTION

The object of the instruction in this Department is not only to familiarize the student with modern shop operations and processes, and with the workability of materials used in engineering construction, but more particularly to give him instruction in the principles of manufacturing and duplication of parts, and in the selection and arrangement of shop equipment.

In the freshman year the student receives instruction in the foundry in moulding, core making, mixing of metals, operation of cupola, the uses of moulding machines, etc., with consideration given to the methods and appliances for sweepwork, large work, and production in quantities; and he is given manual instruction in the forging and heat treatment of both iron and steel, supplemented with illustrations of drop-hammer work and methods used in manufacturing in large quantities.

In the sophomore year wood working is taught with the object not only of familiarizing the student with wood-working tools and machines and their use, but more especially to teach him pattern and core-box making. Instruction is also given in large pattern work and sweepwork.

In the junior year the principles of manufacturing are taught, supplemented by work of an illustrative character in the machine shop, where carefully graded instruction is given in the use of measuring instruments, hand tools, and machine tools, including semi-automatic and automatic machines, and in the use of jigs and special fixtures for manufacturing in large quantities. The administration of this shop in particular is intended to illustrate as far as possible approved methods of shop management and operation, and to give the student a general idea of time keeping, piece work, premium plan, and other wage systems. The instruction is given to a great extent in connection with the construction of commercial machines.

2. DEPARTMENT OF MACHINE DESIGN

The courses in drawing, design, and shopwork, are organized to secure close correlation. Many of the exercises in the drawing room, pattern shop, foundry and machine shop involve work on the same machine parts. In this way the student has presented to him all the necessary steps from the inception to the production of finished machine parts.

Instruction in this Department begins with lettering, the use of drawing instruments, the elements of mechanical drawing according to the best practice in commercial drafting rooms, and descriptive geometry.

Following this the student is taught empirical design and the principles of mechanism. The drawing-room work in the latter course is closely related to the class-room instruction in cams, gearings, and linkages, with application to the kinematic design of machines.

After the student has received instruction in mechanism and applied mechanics, he takes up the mathematical side of machine design, the instruction being given by lectures, recitations, and drawing-room work. The student "lays-out" mechanisms on the drawing board, analyzes the force, velocity, and energy transformations involved, proportions the members with consideration of strength, rigidity, shop operations, and makes working drawings for the complete designs of machines.

The Department offers two of the optional groups that are open to seniors. The first includes instruction in the design of industrial structures and in the selection and arrangement of equipment for factories, power plants, etc. The second senior option offers instruction in ship design and construction, and includes both lectures and drafting-room work bearing on the theoretical and practical design of ships and also a discussion of the important features in the resistance, propulsion, and powering of vessels.

3. DEPARTMENT OF MECHANICS OF ENGINEERING

Instruction is given in this department in theoretical and applied mechanics beginning with a course for sophomores in the fundamental principles of statics and kinetics, with application to mechanisms, followed by a comprehensive study of the mechanics of materials with their application to engineering design. An effort is made to teach students to think rather than to memorize. With this in view, the free-body method is used in the solution of problems involving forces, and students are required to work from fundamental definitions and principles rather than from formulas.

For juniors a course in hydraulics is given. A broad knowledge of the fundamental principles is deemed of more value than familiarity with special formulas or numerical coefficients. For seniors an elective course on hydraulic turbines is offered. While the theory of turbines is outlined, stress is laid upon the practical side of the subject, the object being to make the course of definite value for those expecting to take up hydro-electric work. The laboratory instruction in hydraulics is given in the Department of Experimental Engineering.

4. DEPARTMENT OF HEAT-POWER ENGINEERING

All students in Sibley College receive instruction in this department in their junior and senior years with the object of training them in the methods of solution of problems involved in the theory, design, and economics of heat engines and their auxiliary apparatus, considered both separately and in combination in power plants.

The work of this department begins with lectures and recitations on the elements of heat-power engineering, including the study of the elementary thermodynamics of gases and vapors, theoretical and actual cycles, and steam engines. This is followed by a study of steam turbines, internal combustion engines, fuels and combustion, furnaces, boilers, draft apparatus, producers, heat transmission, condensers, feed-water heaters and other power-plant auxiliaries, the flow of gases and vapors, refrigeration, and air compressors.

In addition to taking these required courses, the student in his senior year may specialize in the design of steam engines or of internal combustion engines, by taking the lecture and drafting courses specially devoted to these subjects. He may also attend special lecture courses on steam turbines, steam boilers, gas manufacture, refrigeration, heating and ventilating, and motor car construction.

5. DEPARTMENT OF EXPERIMENTAL ENGINEERING

A. Mechanical Laboratory Division

Instruction in this department begins in the sophomore year with the study of materials of engineering, their manufacture, properties, and uses.

Throughout the junior and senior years the student receives instruction in the very completely equipped mechanical laboratories (described on page 9) not only to familiarize him with the various types of testing apparatus and to give him skill in their use, but to teach him the best methods of research. Briefly, the courses include the use of computing machines; the testing of engineering materials, with determination of influences of composition and heat treatment; the calibration and use of indicators, gauges, thermometers, dynamometers, etc.; tests of lubricants; fuel calorimetry; steam calorimetry; valve setting; tests of boilers, steam engines, turbines, pumps, heaters, condensers, injectors, and other steam apparatus; tests of air compressors and refrigerating machines; tests of external and internal combustion gas and oil engines; and tests of hydraulic machinery.

B. Engineering Research Division

Engineering research by undergraduate students is carried on in this department under the supervision of a separate corps of specialists who devote their entire time to this work. Students who have shown proficiency in experimental engineering may have opportunity to conduct original investigations under expert guidance, and, as occasion offers, may assist in commercial tests, made at the University or elsewhere, of materials, prime movers, power plants, etc. The equipment of every department is available for this work and the specialists in any department may be consulted.

In case the investigation or research is sufficiently extended, the student is encouraged to embody the work in a thesis. Research, or Thesis, may be elected during the senior year by a limited number who have shown special ability for investigation. Arrangements for this work should be made with the department during the junior year, if possible.

This department will co-operate in every way to assist graduate students in mechanical, electrical and industrial engineering and will aid in providing apparatus and other facilities for graduate work.

6. DEPARTMENT OF ELECTRICAL ENGINEERING

Instruction in electrical engineering begins in the sophomore year, and is based on the required courses in Physics and Mathematics.

In the junior year the fundamental principles are emphasized and the subject developed by elaborating on these principles, rather than by the use of mathematical equations. Both direct and alternating current circuits and machinery are taken up. The theory is given in experimental lectures, and is applied to short design problems in the computing room. In the laboratory the student handles machinery, selects his own instruments and control apparatus, and makes the necessary tests to check the theoretical work.

For those senior students who are specializing in mechanical engineering a brief advanced laboratory and problem course is provided for the solution of such electrical problems as are encountered in general engineering practice.

The principal part of the work for the senior electrical students is given in a well balanced course in which advanced theory, problem work, design and laboratory practice combine to train the student along broad lines. The electrical laboratory being very flexible lends itself particularly to the development of resourcefulness and initiative on the part of the students. A moderate amount of special work is provided for by elective courses in electric traction, illumination, wireless telegraphy, etc., in which the classes are small and more time is devoted to these subjects than is possible in more general courses.

7. DEPARTMENT OF INDUSTRIAL ENGINEERING

Until recently the field of the mechanical engineer was a comparatively narrow one and comprised mainly the design, construction, and operation of machinery. As industry had developed, however, many technically trained men have entered the fields of manufacturing, selling, and administration. This is a natural and increasing tendency since industrial development rests mainly upon a scientific basis. There are few lines of human activity to-day that are not connected in some way with applied science and this is particularly true of those lines known by the general term of engineering.

The success of the engineer in times past in meeting these commercial requirements, for which he had received no special training, was probably due to the method of attack characteristic of the engineer and to superior knowledge of the technical side of the work. But the commercial demands upon the engineer are now becoming so great that special training is necessary to equip him more completely for this larger field. This becomes more evident when it is considered that a large number of the graduates of mechanical engineering colleges go into the commercial side of engineering.

Therefore, in addition to training in the fundamental principles of engineering, every student in the regular courses in Sibley College is given some work in industrial organization and administration before he graduates; but in this department of Industrial Engineering a more complete provision is made in the senior year for those who wish to specialize in manufacturing or the commercial side of engineering.

The work of the department begins in the junior year in which all students in the college are given a course of instruction in the basic principles of industrial organization. An optional group of studies is offered in the senior year for those who wish to specialize somewhat in this line of work, this option consisting of the engineering subjects required in all senior options, special courses of lectures and drawing room work in plant organization and arrangement, and a carefully selected group of economic studies treating of accounting, business law, industrial history, and kindred subjects.

• NONRESIDENT LECTURERS

Supplementing the regular course of instruction, lectures are delivered from time to time by nonresident specialists in the profession on various subjects relating to the many branches of mechanical and electrical engineering. The student may also attend the many public scientific lectures given in other departments of the University by nonresident lecturers.

COURSES OF STUDY

The following courses of study are offered:

1. The regular course leading to the degree of mechanical engineer and covering a period of four years (see page 25 for the first three years of the course). In the senior year of this course the student may specialize in:

Electrical Engineering (page 26)

Heat-Power Engineering,—Steam, Gas, etc. (page 27)

Structural and Plant Engineering (page 27)

Ship Design and Construction (page 28)

Industrial Engineering (page 29).

2. Under certain conditions of entrance, graduation in $4\frac{1}{2}$ years, or 4 years and one Summer Session is possible, see page 17. No definite course of study is laid down for this case.

3. A five-year course leading to the degree of Mechanical Engineer (see pages 29 and 30).

4. A six-year course, in which the student is registered in the College of Arts and Sciences during his first three years of residence. The six-year course leads to the degree of Bachelor of Arts at the end of the fourth year and to the degree of Mechanical Engineer at the end of the sixth year (see page 31).

REQUIREMENTS FOR GRADUATION

The M.E. degree is conferred on candidates who have fulfilled the following requirements:

1. The candidate must have been in residence and registered in Sibley College for at least two terms and must have satisfied the University requirements

in Military Training (or Physical Culture) and in payment of tuition and fees.

2. If admitted to the four-year course, he must have completed to the satisfaction of the faculty of Sibley College all the subjects, including the elective hours, prescribed in the four-year curriculum as outlined by that faculty.

3. If matriculated in a course requiring four years and one term to finish, he must have completed the requirements for the four-year course and seventeen additional hours of work, exclusive of the required drill.

4. If matriculated in the five-year course, he must have completed the requirements for the four-year course and thirty-four additional hours of work, exclusive of the required drill.

5. A student who transfers to Sibley College, after having spent one or more terms in another College of Cornell University, must conform to the requirements for graduation that would have applied if he had been registered in this College from the time he matriculated in the University.

COURSES LEADING TO THE DEGREE OF MECHANICAL ENGINEER

1. THE REGULAR FOUR-YEAR COURSE

In the fourth year in all courses, opportunity is offered for specializing in the different branches of mechanical, electrical, and industrial engineering. The sequence of subjects and the time devoted to each course are given in the following tables. Detailed descriptions of the courses are given on pages 32 to 46, and the requirements for admission are stated on page 15.

NOTE: In referring to courses the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X; Electrical Engineering, E; Industrial Engineering, I. From two and one-half to three hours per week of actual work in shops, laboratories, computing work, or drawing count as one hour credit in the schedule.

Freshman Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytic Geometry and Calculus . .	32	6	6	6
Chemistry	33	I	0	6
Physics	32	3	6	0
Drawing and Des. Geom.	35	D I, 2	3	3
Foundry	35	S3	2 or 0	0 or 2
Forge	35	S4	0 or 1	1 or 0
Engineering Principles	39	P1	1	1 or 0
Military Drill	34	I	1	1

Sophomore Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	38	M5, 6	5	5
Physics, Recitations	32	I1	4	0
Physics, Laboratory	32	I4	2	2
Electrical Engineering	43	E 5	0	2
Chemistry	33	6	0 or 5	5 or 0
Kinematics	36	D6	0	2
Drawing	36	D5, 7	3	3
Materials	41	X6	3 or 0	0 or 3
Pattern Making	35	S7	3 or 0	0 or 3
Military Drill	34	I	1	1

Junior Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Heat-Power Engineering	39	P10	3	3
Electrical Engineering	43	E14	2	2
Electrical Engineering	43	E15	2	2
Mechanical Laboratory	41	X10, 11	3	3
Machine Design—(a) Drawing . . .	36	D10	2	2
(b) Lectures and Recitations . . .	36	D16	3	3
Machine Work	35	S10	2	2
Industrial Organization	45	I 12	0	0
Hydraulics	39	M12	2	2

Senior Year

In the senior year the regular student must complete one of the options (A to E inclusive) outlined on the following pages. All these options include courses in Power Plant Design, Mechanical Laboratory, Electrical Engineering, and Economics; and under each option are lecture and drafting courses devoted to the special work of the option. In addition, provision is made in most of the options for limited election of courses given in any college of the University.

Option A. Electrical Engineering

This option is planned to give the thorough grounding in electrical engineering required by engineers connected with the design, construction, and operation of the electrical part of engineering properties.

The theoretical work in courses E 20 and E 21, together with the design and laboratory work, forms a well balanced course of study along broad lines. A moderate amount of special work is provided for by the elective courses.

A large proportion of the work in mechanical engineering is also taken by those who elect electrical engineering, so that the student is not limited in his outlook and in his choice of work after graduation.

Senior Electrical Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	39	P 20	3	0
Mechanical Laboratory	42	X 22	2	0
Economics	33	52	2	2
Electrical Machinery	43	E 20	2	2
Electrical Machinery	43	E 21	3	3
Electrical Design	44	E 22	2	2
Electrical Laboratory	44	E 28	4	4
Electives (or Thesis, X 32, page 42)*	31		2	5

*Not more than four hours credit in Advanced Military Science (in addition to the four hours of Drill regularly required of first- and second-year men) will be accepted toward meeting the requirements for the M.E. degree.

Option B. Heat-Power Engineering

The object of this option is to train men in the design of steam and internal combustion engines and auxiliary apparatus, and also in the design and arrangement of heat-power stations.

The special work of this option includes the theoretical and practical consideration of types, arrangements, general proportions and details of steam and internal combustion engines, and their auxiliaries; the design of engine parts, valve gears, governors; balancing, determination of flywheel weights; and the selection and arrangement of machinery for steam and internal combustion power plants. This work is taught by lectures which are supplemented by a drafting course. In addition, among the elective courses, the student may include courses on Boiler Design, Steam Turbines, Gas Manufacture and Transmission, Refrigeration, Heating and Ventilating, and Motor Car Construction.

Senior Heat-Power Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	39	P 20	3	3
Mechanical Laboratory	42	X20, 21	3	3
Electrical Engineering	45	E 36	2 or 0	0 or 2
Electrical Engineering	45	E 37	0 or 2	2 or 0
Economics	33	52	2	2
Heat-Power Machinery Design. . .	40	P 23	3	3
Drawing and Design	40	P 24	2	2
Steam Turbines	40	P 25	0	2
Elective(or Thesis, X 32, page 42)*	31		4	2

Option C. Structural and Plant Engineering

The object of this option is to train students in the solution of problems of design, construction and equipment of modern industrial and power plants, including buildings. The first part of the course treats of the graphics of construction as applied to trusses and similar structures. This is followed by instruction in the theory and practice of footings, foundations, sidewalls and other details to be designed in planning industrial works. The second part of these courses is devoted to the selection and arrangement of machinery, using the knowledge of machines that the student has acquired in other courses as a guide in selecting the proper units. Each student is required to make a layout of an industrial plant, or a power house, making the skeleton outline of the buildings, selecting and locating the machinery and carrying the design to the point usually required in preliminary design.

Among the optional hours the student may, if he desires, include the elective courses in Steam Boilers, Steam Turbines, Gas Power Machinery, Engineering Notes, Refrigeration, and Heating and Ventilating.

*See footnote, page 26.

Senior Structural and Plant Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	39	P 20	3	3
Mechanical Laboratory	42	X 20, 21	3	3
Electrical Engineering	45	E 36	2 or 0	0 or 2
Electrical Engineering	45	E 37	0 or 2	2 or 0
Economics	33	52	2	2
General Engineering Design	37	D 22	2	2
Drawing and Design	37	D 23	3	3
Elective (or Thesis, X 32, p. 42)* . .	31		4	4

Option D. Ship Design and Construction

The primary purpose of Option D is to train men who intend to enter shipyards to make a life work of ship design and construction, but it may be taken profitably by men intending to follow other lines of mechanical engineering.

In this option the fundamental principles underlying the design of all the types of mercantile, war, and pleasure vessels are discussed in detail. This is productive of problems in hydro-statics, hydro-dynamics and aero-dynamics, the solutions of which are deeply interesting, not only to the Naval Architect but to the Mechanical Engineer.

The materials used in the construction of vessels, their equipment, and their machinery, are taken up and their economic and structural values determined.

The speed and powering of vessels are fully dealt with along the lines indicated by the results derived from the latest experimental research, as well as those obtained from experience with actual vessels.

The different types of propelling machinery are critically examined from the standpoint of their adaptability in the three classes of vessels referred to above.

Specifications, contracts, and the organization of shipyards, docks, and engineering shops, form the subjects of interesting and useful discussions.

Senior Ship Design and Construction Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	39	P20	3	3
Mechanical Laboratory	42	X 20, 21	3	3
Electrical Engineering	45	E36	2 or 0	0 or 2
Electrical Engineering	45	E37	0 or 2	2 or 0
Economics	33	52	2	2
Ship Design	37	D25	3	3
Speed and Power of Ships.	37	D26	0	2
Drawing and Computation	38	D27	3	3
Specifications, Contracts, etc.	38	D28	2	0
Elective*	31		0	2

*See footnote, page 26.

Option E. Industrial Engineering

This option is intended for those who wish to enter the commercial side of engineering or who are particularly interested in industrial organization and administration. In the special courses relating to this option are discussed the modern time-keeping and cost-finding systems, methods of planning work and insuring production, time and motion studies, purchasing, problems in administration, plant locating, heating, lighting, powering, safety engineering, fire protection and similar subjects. In the drafting and designing course the graphical work includes the application of these fundamental principles to planning industrial enterprises. The time allotted to economics will be devoted to such courses as accounting, business law, government control of industry and financial history. Students who wish to elect this option must receive credit for Elementary Economics 52, or its equivalent, before the senior year, since this is a prerequisite for some of the courses required in the option. Students expecting to elect this option are also advised to read for preparation as much industrial history and kindred subjects as possible.

Senior Industrial Engineering Option:

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Power Plant Design	39	P 20	3	3
Mechanical Laboratory	42	X20, 21	3	3
Electrical Engineering	45	E36	2 or 0	0 or 2
Electrical Engineering	45	E37	0 or 2	2 or 0
Industrial Administration	45	I20	2	2
Drawing and Design	46	I22	3	3
Safety Eng'g and Fire Protection .	46	I23	0	2
Accounting		58 a	3	0
Electives*	31		0	3

2. REGULAR FIVE-YEAR COURSE†

The requirements for admission to the five-year course leading to the degree of Mechanical Engineer are given on page 17.

The optional hours in the five-year course make it possible for the student either to elect subjects of cultural value, or to specialize to a limited extent in some branch of science in which he may be particularly interested, such as Economics, Chemistry, Physics, and Geology; or the student may include some of the elementary courses in Civil Engineering or in Architecture.

The outline of the first two years gives the subjects which must be taken in order that the student may enter the third year properly prepared for the engineering work. It is essential that the student should follow the sequence of subjects as given in this outline, for otherwise it may be impossible for him to complete the requirements for the degree by the end of the fifth year.

Students in this course are required to carry at least 17 credit hours a term exclusive of drill. First year students are limited to a maximum of 19 hours a term, and second year men to 20 hours.

*See footnote, page 26.

†For requirements for graduation, see page 24.

NOTE. In referring to courses of instruction the following abbreviations are used: Shop, S; Machine Design, D; Mechanics of Engineering, M; Power Engineering, P; Experimental Engineering, X. For description of courses given by other colleges, see the announcements of those colleges. From two and one-half to three hours per week of actual work in shops, laboratories, or drawing count as one hour credit in the schedule.

First Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
English	34	I	4	4
Advanced Algebra†.	32	2	5	0
Solid Geometry†.	32	I	0	3
Trigonometry†.	32	3	0	3
Chemistry	33	I	0	6
Engineering Principles	39	P1	1	0
Forge Shop.	35	S4	0	1
Foundry	35	S3	2	0
Elective in Arts and Sciences			5	0
Military Drill	34	I	1	1

Second Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Analytical Geometry and Calculus	32	6	6	6
Chemistry	33	6	5	0
Physics	32	3	0	6
Drawing	35	D1, 2	3	3
Elective in Arts and Sciences			3	2
Military Drill	34	I	1	1

Third Year

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Mechanics of Engineering	38	M5, 6	5	5
Physics, Recitations	32	II	4	0
Physics, Laboratory	32	14	2	2
Electrical Engineering	43	E5	0	2
Kinematics	36	D6	0	2
Drawing	36	D5, 7	3	3
Materials	41	X6	3	0
Pattern Making	35	S7	0	3
Elective in Arts.			3	0

Fourth and Fifth Years

The fourth and fifth years are identical with the third and fourth years of the regular four-year course (see pages 26 to 29).

†If credited in this subject at the time of admission, an equivalent number of hours may be elected in some other subject.

3. A SIX-YEAR COURSE LEADING TO THE DEGREES OF A.B. AND M.E.

A student in the College of Arts and Sciences who has satisfied at least six terms of residence, may with the permission of the faculties concerned be registered both in the College of Arts and Sciences and also in any other college of Cornell University. This provision enables a student who so desires, to obtain the degree of A.B. from the College of Arts and Sciences at the end of four years, and the degree of M.E. from Sibley College at the end of six years. Advice and assistance in arranging such a course may be had by applying to the Dean of Sibley College and the Dean of the College of Arts and Sciences.

In order to make it possible to secure the M.E. degree at the end of the sixth year, the student must complete the freshman engineering subjects (page 25) before the beginning of his fourth year, and must complete the list of sophomore subjects (page 25) before the beginning of his fifth year.

ELECTIVES

Students having the necessary preparation and having the approval of their class adviser may take any subject in any department in the University. For detailed information regarding these elective subjects see the announcements of the Departments in which they are given.

TECHNICAL ELECTIVES GIVEN IN SIBLEY COLLEGE FOR SENIORS ONLY

Course	Page	No. Course	Hours 1st Term	Hours 2d Term
Thesis	42	X32	0-8	8-0
Steam Boiler Design	40	P30	2	0
Steam Turbines	40	P25	0	2
Gas Power Machinery	40	P29	2	2
Motor Car Construction	40	P32	0	2
Heating and Ventilating	40	P33	2	0
Engineering Research.	42	X30	1-3	1-3
Engineering Notes	37	D24	0	2
Speed and Power of Ships	37	D26	0	2
Advanced Designing.	38	D40	1-3	1-3
Industrial Administration	45	I20	2	2
Safety Eng'g and Fire Protection . .	46	I23	0	2
Central Stations	44	E 23	0	2
Elem. of Elect. Ry. Pract.	44	E25	0	2
Wireless Telegraphy	44	E27	0	2
Special Elect. Eng. Problems.	45	E33	1-3	1-3
Engineering Mathematics	44	E 30	2	2
Hydraulic Turbines	39	M21	2	0
Sibley Journal Credit	42	X40	0 to 2	0 to 2

COURSES OF INSTRUCTION

SUBJECTS GIVEN IN THE COLLEGE OF ARTS AND SCIENCES*

For hours see the Announcement of the College of Arts and Sciences.

Mathematics

Examinations for the removal of conditions in mathematics 1-8 are held in September just before registration. Similar examinations are held in April for the removal of conditions incurred at the end of the first term. For further information apply to the Department.

1. **Solid Geometry.** Repeated in second term, credit three hours. Professor Tanner in charge.

Open to all students, but designed especially for those who have entered with the minor requirements in mathematics and are preparing: (a) to teach mathematics in the secondary schools; (b) to take up engineering work later in the course; (c) to specialize in chemistry or physics.

2. **Advanced Algebra.** Repeated in second term, credit five hours. Professor Tanner in charge.

Open to all students, but designed especially for those mentioned under course 1.

2 (E). **Advanced Algebra.** First term, credit three hours.

Open to students who have met the entrance requirements in intermediate algebra. The work covered is the equivalent of that required in this subject for admission to course 6. Professor Tanner in charge.

3. **Plane Trigonometry.** Repeated in second term, credit three hours. Professor Tanner in charge.

Open to all students, but designed especially for those mentioned under course 1.

6. **Analytic Geometry and Calculus.** Throughout the year, credit 6 hours each term. Twenty-four sections daily. Under the direction of Professor TANNER. The first term's work in this course is also offered in the second term and the second term's work in the first term of the following year.

Physics

3. **Introductory Experimental Physics.** Repeated in second term, credit six hours. Prerequisite courses Advanced Algebra and Trigonometry. Three lectures and three periods in laboratory and class-room a week. Lectures: Professors MERRITT and GIBBS and ———; Laboratory and class-room work: Assistant Professor HOWE and assistants.

Entrance Physics will not be accepted as an equivalent of this course.

11. **General Physics.** Theory. First term, credit four hours. Prerequisite courses Math. 6 and Phys. 3. Assistant Professor BIDWELL and other members of the instructing staff. Four recitations a week as assigned. Rockefeller as assigned. Text-book and problem work in dynamics, temperature measurement, and electricity.

*Only those subjects that are included in the regular four-year and five-year courses are given. For the other subjects see the Announcement of the College of Arts and Sciences.

14. Physical Experiments. Throughout the year, credit two hours a term. One laboratory period per week. Must be accompanied or preceded by Phys. 11. Must be preceded by Math. 6 and Phys. 3. Assistant Professor BIDWELL, and Messrs. HYATT, HALPERIN, KITTREDGE, KOLLER, LITTLEWOOD, and MERTZ. Rockefeller 250-257 as assigned.

Physical measurements, properties of matter, mechanics, heat; light, sound, magnetism, and electricity; the adjustment and use of instruments of precision. Results and errors are carefully discussed.

ADDITIONAL COURSES IN PHYSICS

In addition to the courses mentioned above which are required of students in Sibley College, the Department of Physics offers courses in advanced general physics, alternating currents, photometry and illumination, high temperature measurements, aerodynamics and the mechanics of flight, electric waves and the physics of radio communication, X-rays, etc. For details, see the announcement of the College of Arts and Sciences.

Chemistry

1. Introductory Inorganic Chemistry. Lectures, recitations. and laboratory. Second term, credit six hours. Not open to Sibley students in the first term.

1a. Lectures, M W F, 9-11, Professor BROWNE and Mr. GRIFFIN. Professor BROWNE and Mr. MCCOY.

1b. Recitations (one hour a week to be arranged). Laboratory (two 2½-hour periods per week); Second term, M F, 2-4.30; T Th, 2-4.30; W, 2-4.30; and S, 8-10.30. Professor BROWNE, Dr. FOGLESONG, and Messrs. COLONY, FLETCHER, HEMPHILL, SCHACK, FLINT, and BULL.

Entrance credit in chemistry does not carry with it University credit in course 1. If a student entering the University from a preparatory school desires credit in course 1 he must pass an examination set by the Department of Chemistry. This examination is held both in New York City and in Ithaca on the same day in September as the entrance examination. University credit in course 1 that is obtained by passing this examination does not carry with it entrance credit in chemistry.

Examinations for those who were unavoidably absent from the final examination in course 1 will be held at 2 p. m. on the day before instruction begins in the fall.

6. Qualitative and Quantitative Analysis. Repeated in second term, credit five hours. Prerequisite course 1. Messrs. RIDER, LOUDER, BRANDES, LEPPART, BARRETT, and HUBACH. Lectures and recitations: T Th, 12. Laboratory sections M W F, 2-5; T Th S, 8-11; T Th S, 9-12.

Qualitative work: the properties and reactions of the common elements and acids and their detection in various liquid and solid mixtures.

Quantitative work: the preparation and use of volumetric solutions and work in elementary gravimetric analysis.

Examinations for those who were unavoidably absent from the final examination in course 6 will be held at 2 p. m. on the day before instruction begins in the fall.

Economics

52. Elementary Economics. Throughout the year. Credit two hours a term. One lecture and one recitation each week. Lectures and recitations, as assigned. Mr. CAMPBELL.

English

1. Introductory Course in English. Required of Five-Year students. Throughout the year, credit four hours a term. Students who have not taken the course in the first term may enter in the second term in sections provided for them. Open only to underclassmen who have satisfied the entrance requirement in English. Freshmen who are candidates for the degree of Bachelor of Arts will ordinarily take course 3, and may not enroll in course 1 except with the consent of the head of the department. Assistant Professor SMITH; Dr. GILBERT; Messrs BUNDY, BRADLEY, LONG, MANNING SMITH. Twenty-eight sections. Hours as assigned. Rooms to be announced.

A study of representative works in English literature, including four plays of Shakespeare, two modern novels, selected essays, and poems of Milton and Tennyson. Practice in composition in connection with the reading, with incidental study of the principles of writing. Registration in the course is in charge of Assistant Professor SMITH.

Students who elect English 1 must apply at Goldwin Smith A on Monday, Tuesday, or Wednesday of registration week for assignment to sections.

Military Science and Tactics

1. Practical and Theoretical Military Training. Throughout the year, credit one hour a term. Two hours drill on one of the first four afternoons of the week, and one hour on Friday at 4.45 P. M.

Every male student, a candidate for a baccalaureate degree, except in the College of Law, who is required to take five, six, seven, eight or more terms in residence, must take, in addition to the scholastic requirements for the degree, one, two, three, or four terms respectively of three hours a week in the Department of Military Science and Tactics, except as provided below.

A holder of a college degree is exempt from the entire requirement. A student who is admitted from another college to take at Cornell four or less terms for his degree is exempt from the entire requirement. A student excused by the Military Department from one or more terms of required drill must substitute therefor a corresponding number of terms of Physical Training. A student may be permanently excused from Drill or Gymnasium by the Medical Adviser, or by the Committee on Excuses from Physical Training and Military Science, and in such case the student shall not be required to make substitution for this work. No credit will be given for Drill to any student who has received his instruction in the subject in an institution other than that of college rank.

The requirements in Military Science must be completed in the first terms of residence; otherwise the student will not be permitted to register again in the University without the consent of the University Faculty.

The aim of the Department is to prepare graduates for becoming officers of a reserve or volunteer force. The students are organized into companies and a band for a course of training prescribed by the War-Department.

This course includes physical training, rifle shooting, military drill, and the application of fundamental principles of modern infantry tactics. During the second year qualified men may be given optional instruction in units specializing in signal corps, military engineering, and machine gun training. The band is both

the cadet and university band, and students regularly enrolled in the Department may be assigned thereto for training instead of to a company.

2. **Elective Military Training.** Throughout the year, credit two hours a term. Drill Hall. Prerequisite 4 terms of course 1 or its equivalent.

An advanced course covering practically and theoretically the duties of officers and non-commissioned officers with the units represented in the Department.

Physical Training

1. **Physical Training.** Required of Freshmen excused from drill. Throughout the year, three periods weekly.

2. **Physical Training.** Required of Sophomores excused from drill. Throughout the year, three periods weekly.

3. **Boxing and Wrestling.** Daily except Saturday. A special fee of \$5 a term is charged for instruction in each branch.

For the required work in Physical Training see the Gymnasium Handbook issued by the department.

SUBJECTS GIVEN IN SIBLEY COLLEGE

From two and one-half to three hours in shops, laboratories, computation work, or drawing count as one credit hour in the schedule.

DEPARTMENT OF MACHINE CONSTRUCTION

S. 3. **Foundry Work.** Freshmen. Either term, credit two hours. Five hours of work a week. Moulding, core making, mixing, and casting of metals, use of moulding machines. Demonstrations of large work and production in quantities. Messrs. VANDERHOEF and Assistant.

S. 4. **Forge Work.** Freshmen. Either term, credit one hour. Two and one-half hours of work a week. Forging, welding, tool dressing, tempering, etc., together with demonstrations in the production of drop forgings. Messrs. HEAD and Assistant.

S. 7. **Pattern Making.** Sophomores. Either term, credit three hours. Seven and one-half hours of work a week. Prerequisite course S. 3. Use of hand and machine tools for wood working, followed by graded instruction in pattern making, construction of core boxes, etc. Mr. HOOPER and Assistants.

S. 10. **Machine Work.** Juniors. Throughout the year, two hours credit a term. Six hours of work a week. Prerequisite course S. 3, 4, and 7. Use of measuring instruments, hand and machine tools, fitting, and assembling. Operation and use of jigs and other manufacturing fixtures. Operation of semi-automatic and automatic machines and the illustration of manufacturing methods generally. Professor WELLS, Mr. GREEN, and Assistants.

DEPARTMENT OF MACHINE DESIGN

D. 1. **Drawing.** Required of freshmen. First term, credit three hours. Eight hours of work a week. Lettering (proficiency in at least one style of simple lettering); mechanical drawing; working drawings, including conventions,

standards, etc., following the best commercial practice. Assistant Professor HAM and Instructors.

D. 2. Descriptive Geometry. Required of freshmen. Second term, credit three hours. Eight hours of work a week. Lecture and drawing periods. The course includes points, lines, planes, solids, tangents, intersections, and developments, with solutions in all quadrants; isometric projections, with practical applications. Assistant Professor HAM and Instructors as in D 1.

D. 3. Drawing. For students registered for the degree of Bachelor of Chemistry. First term, credit three hours. Eight hours of drawing a week. Lettering, mechanical drawing, working drawings, including conventions, standards, etc. Similar to Course D. 1 but modified to suit the needs of students registered as above. Assistant Professor HAM and Instructors.

D. 5. Machine Drawing. Sophomores. First term, credit three hours. Eight hours of drawing a week. Prerequisite course D. 1. Application of the work of course D. 1 to machine drawing in connection with empirical designing; proportioning of machine details as fixed by common practice rather than by mathematical theory; making and using standard data sheets; making of assembly drawings. Assistant Professor ROGERS, and Instructors.

D. 6. Kinematics. Sophomores. Second term, credit two hours. Prerequisite courses D. 1 and 2, and must be taken with course D. 7. Two recitations a week on the theory of mechanisms, instant centers, cams, gears, linkages, velocity and acceleration diagrams, etc. Assistant Professor ROGERS and Instructors.

D. 7. Kinematic Drawing. Sophomores. Second term, credit three hours. Eight hours of drawing a week. Prerequisite courses D. 1 and 2, and must be taken with course D. 6. Drawing board application of the work in course D. 6. Solution of mechanisms by means of instant centers, the designing of cams, gears, linkages, etc., drawing of velocity and acceleration diagrams, etc. Assistant Professor ROGERS and Instructors.

D. 10. Drawing and Design. Juniors. Throughout the year, credit two hours each term. Six hours of drawing a week. Prerequisite courses D. 5, D. 6, D. 7, M. 5 and 6, and must be taken with course D. 16. Drawing room problems in elementary machine design illustrating the work as given in D. 16. The student for the first time undertakes the design of a complete machine, laying out the general outlines, proportioning the details theoretically, and modifying his results by practical considerations. All computations necessary for the complete design must be carefully and systematically made. Working drawings of the most important details and a finished assembly drawing are completed. Professors KIMBALL and ALBERT, and Instructors.

D. 16. Machine Design. Juniors. Throughout the year, credit three hours a term. One lecture and two recitations a week. Prerequisite courses D. 5, 6, 7, M. 5 and 6, and must be taken with D. 10. Selection of mechanism for specified work and study of practical considerations involved. Analysis of energy and force problems in machines. Determination of driving devices as based on work to be done. Proportioning of detail parts as dictated by stress and practical considerations. Applications of the laws of mechanics and kinematics to the design of machines, and a discussion of empirical design and modifi-

cations due to practical considerations. Professors KIMBALL and ALBERT, and Instructors.

D. 22. **General Engineering Design.** Required of seniors in Option C. Throughout the year, credit two hours a term. Lectures. Prerequisite courses D. 10, D. 16, and P. 10, and must be taken with D. 23. For students who do not wish to specialize in any particular branch of engineering but wish to get a general knowledge of mechanical engineering design and construction. The work of the first term consists of a discussion of the problems met with in the design, construction, and equipment of mills, factories, etc., including foundations, walls, floors, trusses, roofs, and mill construction work in general; powering of factories, motor driving of machine tools, etc. In the second term this work is applied to the outline design of a complete power house, including the location of plant; track and wharf facilities; selecting and locating boilers and engines; coal storage, coal and ash handling equipment; selection and arrangement of condensers, pumps, steam piping, etc. Assistant Professor LEE and Mr. TOWNSEND.

D. 23. **Drawing and Design.** Nine hours of work a week throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16 and P. 10, and may only be taken in connection with D. 22. Design and drawing of various classes of work illustrating the principles discussed in D. 22. Graphical analysis of stresses in trusses and other structures. In the second term, drawings are made for the complete outline design of a power house as discussed under course 22. Assistant Professor LEE and Mr. TOWNSEND.

D. 24. **Engineering Notes.** Elective for seniors. Second term, credit two hours. Prerequisite courses D. 10 and 16. Lectures on some practical problems encountered in the everyday work of the engineer, solutions of these being arrived at by a reference to actual experience in different branches of engineering. Problems illustrative of the application, in combination, of the three qualifications of the successful engineer, i. e., theory, practice, and common-sense. Professor McDERMOTT.

D. 25. **Ship Design.** Required of seniors in Option D. Lectures throughout the year, credit three hours a term. Prerequisite courses D. 10 and 16. The lectures of the first term deal with the conception and derivation of the elements of form; hydro-static principles underlying the design of vessels; methods of computing the geometrical quantities—displacement, centers of buoyancy, metacenters, etc.; tonnage, reserve buoyancy and freeboard; materials used in the construction of vessels; the structural elements of mercantile and naval ships, their functions and inter-relations; construction rules of the leading Classification Bureaus and Navy Departments.

The lectures of the second term deal with the weights, strength and stability of vessels and the methods which are used in practice in estimating these quantities and qualities. Safety of life at sea is given the fullest consideration. Professor McDERMOTT.

D. 26. **Speed and Power of Ships.** Required of seniors in Option D. Second term, credit two hours. Prerequisites D. 10 and 16. Lectures. The fundamental hydro- and aero-dynamics underlying the study of the resistance of vessels—floating, submarine, and aerial—and of the different propelling agents,

chiefly that of the screw-propeller. An analytical discussion of the experiments made on models of ships and propellers in the experimental tanks and laboratories in the United States and abroad, and from the results obtained practical methods and formulas are derived for estimating the resistance and horse-power required for vessels of all types, as also, the most suitable dimensions of propeller. The different types of propelling machinery—steam (reciprocating and turbine), electrical, internal combustion, and their combinations; their mechanical, space and weight efficiencies; and their respective merits reviewed from the propulsive and commercial standpoints. Steam boilers of the firetube and watertube types; their characteristics and suitability for mercantile and war vessels. Professor MCDERMOTT.

D. 27. Design and Drawing. Required of seniors in Option D. Throughout the year, credit three hours a term. Must be accompanied by D. 25. Delineation of the "lines" of a vessel with selected elements of form. Drawing of "scantling" section according to the rules of the American Bureau of Shipping. Computations of geometrical quantities, strength and stability. Estimates of horse-power, weight of vessels and machinery. Professor MCDERMOTT.

D. 28. Specifications, Contracts, etc. Required of seniors in Option D. First term, credit two hours. Prerequisite courses D. 10 and 16. Lectures. Discussion of the headings and principal points to be observed in drawing up specifications and contracts for vessels, their equipment and machinery. Financial, technical, and operative organization of shipyards. Cost systems and methods leading to efficient production. Professor MCDERMOTT.

D. 40. Advanced Designing. For graduates who have had the equivalent of D. 22 and D. 23, or of D. 25, 26, and 27. Advanced work in original design as arranged with Professors KIMBALL, MCDERMOTT, and ALBERT.

DEPARTMENT OF MECHANICS OF ENGINEERING

M. 5 and 6. Mechanics of Engineering. Sophomores. M. 5 in first term M. 6 in second term. Credit five hours a term. Prerequisite course Mathematics 6. Theoretical and applied mechanics, including statics, kinetics, and mechanics of materials; resolution, composition, and equilibrium of forces; statics of rigid bodies, cords and structures; center of gravity and moment of inertia; composition and resolution of displacements, velocities and accelerations; Newton's law; fundamental equations of motion; rectilinear and curvilinear motion of a particle and of rigid bodies; motion diagrams; work, energy, and power, with application to machines; impact; friction; stress and strain; strength and elastic properties of materials in tension, compression, and shearing; torsion; bending moment, safe loading, deflection and resilience in simple and continuous beams; non-prismatic beams; combined bending and torsion; eccentric loading; curved bars and hooks; columns; problems showing application of principles of mechanics in engineering design. Professor WOOD, Assistant Professor GARRETT and Instructors.

M. 12. Hydraulics. Juniors. Second term, credit two hours. Prerequisite courses, M. 5 and 6. Hydrostatics: pressures in containing vessels, centers of pressure, and flotation. Hydrokinetics: flow through orifices and over weirs;

general equation of energy; losses of head; flow in pipes and open channels; and dynamic action of streams. Assistant Professor SWITZER and Assistant.

M. 21. Hydraulic Turbines. Elective. First term, credit two hours. Prerequisite course M. 12. One lecture and one recitation a week. Theory, construction, and installation of modern hydraulic turbines, and a study of their characteristics with a view to intelligent selection of the proper type and size of turbine for any given set of conditions; costs of turbines and water power development. Assistant Professor SWITZER.

DEPARTMENT OF HEAT-POWER ENGINEERING

P. 1. Engineering Principles. Freshmen. Two Lectures a week. Either term as assigned, credit one hour. Discussion of the elementary principles that underlie the development of energy from natural sources and its transmission, control and application to human needs. Dean SMITH and Heads of Departments.

P. 10. Elementary Heat-Power Engineering. Required of all juniors. Throughout the year, credit three hours a term. Prerequisite courses Physics 8, 9, and 14, Chemistry 6, M. 5 and 6, and D. 5, 6, and 7. Two recitations and one lecture a week throughout the year. Thermodynamics of gases and vapors, theoretical cycles and general theory of heat engines; application to steam engines and turbines; practical modifications in real engines; engine efficiencies and performances; the indicator card as a measure of work and basis for design; economic features,—reduction of losses by jacketing, superheating, compounding, etc.; application of unaf flow and locomobile principles; types of engines; governors. On account of the importance of a thorough understanding of this subject, the student is required to solve a large number of problems in the class room. Professor ELLENWOOD and Instructors.

P. 11. Heat Engines and Auxiliaries. Required of C. E. seniors. Either term, credit three hours. Not open to Sibley students. Prerequisite courses Physics 2 and 7, (or the equivalent), Chemistry 1, C.E. 20. One lecture and two recitations a week. Elementary consideration of behavior of gases and vapors. Internal combustion engines. Theory of vaporization. Study of boilers, types of boilers; advantages and disadvantages of various types. Action of vapors in cylinders. Steam engines and turbines; parts and operation; types, advantages and disadvantages; application; steam consumption and efficiencies. Advantages of condensing; types of condensers; condenser auxiliaries. Contractors' plants. Cost of power.

This course is recommended for all students who wish to obtain a general elementary knowledge of heat-power engineering without great technical detail. Professor ELLENWOOD.

P. 20. Power Plant Design. Required of all regular seniors. Throughout the year, credit three hours a term. Prerequisite course P. 10. One lecture and two recitations a week. A continuation of course P. 10.

Steam turbines; internal combustion engines; fuels; principles of combustion; boiler furnaces and grates; heating surfaces of boilers; types of boilers natural and forced draft; producers; principles governing the transfer of heat; feed water heaters; economizers; superheaters; theory of condensation; types

of condensers; condenser pumps; cooling towers and similar devices; water treating apparatus; filters, separators, and similar auxiliary apparatus; flow of steam and gas; refrigerating machinery, and air compressors; elementary theory, types and efficiencies.

Consideration of selection of elements and their combination in power plants, with the object of producing the maximum profit from investment and operation. Professor SMITH, Assistant Professor MATTHEWS.

P. 23. **Heat-Power Machinery Design.** Required of seniors in Option B, and not open to others. Throughout the year, credit three hours a term. Prerequisite courses D. 10, D. 16 and P. 10, and must be accompanied by course P. 24. Discussion of types, arrangements, general properties and details of steam and internal combustion engines and their auxiliaries. Power plants. Professor BARNARD.

P. 24. **Designing and Drawing.** Required of seniors in Option B, and not open to others. Throughout the year, credit two hours a term. Prerequisite courses D. 10, D. 16 and P. 10 and must be accompanied by P. 23. Two drawing periods per week. The practical solution of problems discussed in P. 23. Professor BARNARD.

P. 25. **Steam Turbines.** Senior elective. Required of those taking the design of steam engines in P. 24. Second term, credit two hours. Prerequisite course P. 10. Two lectures a week. Classification of turbines and description of leading features of the various types. Mechanical and thermal considerations underlying the action of steam in turbines. Calculations involved in turbine design. Discussion of building, erecting, and testing. Adaptability to special conditions of service. Economic results of the use of turbines in engineering practice. Professor BARNARD.

P. 29. **Gas Power Machinery.** Seniors. First and second terms, credit two hours. Not open to students taking Option B. Prerequisite courses D. 10, D. 16, and P. 10. Two lectures a week. General theory and salient points in the design and operation of internal combustion engines and gas producers. Description of existing commercial types, study of relative advantages, and consideration of questions of economy. Professor DIEDERICHs.

P. 30. **Steam Boiler Design.** Seniors. First term, credit two hours. Prerequisite courses D. 10, D. 16, and P. 10. Lectures on fuels, combustion, types of boilers, general proportions, materials, design of boiler details, settings, stokers, accessories, and the equipment and arrangement of boiler plants. Professor BARNARD.

P. 31. **Pumping and Refrigeration.** Elective. Two hours, first and second terms. Credit 2 hours each term. A course dealing with the principles of pumping, air compression, and refrigeration. Dean SMITH.

P. 32. **Motor Car Construction.** Elective. Second term, credit two hours. Prerequisites P. 10, D. 10, 16. Two lectures a week, illustrated by lantern slides showing the structure and development of the motor car. Assistant Professor UPTON.

P. 33. **Heating and Ventilating.** Elective. First term, credit two hours. Prerequisites P. 10, D. 10, 16. Lectures and recitations covering the methods of

design and of construction of various forms of ventilating and heating apparatus. Professor SAWDON.

P. 40. **Advanced Heat-Power Engineering.** Elective for those who have completed the equivalent of the design subjects in senior Option B. Work and credit as arranged with Professors SMITH and BARNARD.

P. 41. **Readings in English Literature.** Open to juniors and seniors in Sibley College. Two readings a week from Thanksgiving to Easter recess; one hour credit (to be reported in the second term). Credit toward graduation not to exceed one hour in this course. Professor SAMPSON. (For information regarding the course consult Dean Smith.)

DEPARTMENT OF EXPERIMENTAL ENGINEERING

The work in this Department is given in two divisions. One of these is devoted to courses that are required of all students for graduation; the other relates to research courses that are elective.

A. Mechanical Laboratory Division

X. 6. **Manufacture of Engineering Materials.** Required of sophomores. First or second term, credit three hours. Prerequisite course Chemistry 1. Three lectures a week. Metallurgy of iron and steel, copper, etc. Professor DIEDERICHS.

X. 10. **Mechanical Laboratory—Properties of Engineering Materials.** Juniors. First term, credit three hours. Prerequisite courses X. 6, M. 5 and 6. One laboratory period a week. Mechanical strength of materials; tension, torsion, transverse, and compression tests; the variation of the mechanical strength with differences in composition or heat treatment; demonstration of different methods of tempering, annealing, forging, etc. The student is required to write and submit one report each week upon the experiment of the previous week. Assistant Professor UPTON and Instructors.

X. 11. **Mechanical Laboratory—Introductory Experimental Engineering.** Juniors. Second term, credit three hours. Prerequisite courses M. 5 and 6, Chem. 6, Phys. 3. One laboratory period a week as assigned, one written report a week. Calibration of indicator springs, steam gauges, thermometers, and dynamometers; practice and tests of various computing machines; viscosity and friction tests of lubricants on various testing machines; tests of heating values of coals; steam quality tests, with various forms of calorimeters; measurement of water; efficiency test of steam engines and pumps, feed water heaters, and condensers. Reports are required and these must include all the data and results of the various tests, together with conclusions. The preparation of the report is considered an important part of the course. Assistant Professor UPTON and Instructors.

X. 12. **Mechanical Laboratory.** For students in Chemistry course. Second term only, credit four hours. Prerequisite courses M. 5, and Phys. 10 and 14. One laboratory period (Sat. 8–12) and one report a week. Principal tests on materials of construction; use, adjustment and calibration of common engineering instruments; testing of oils; engine and boiler trials; study of refrigeration, etc. Assistant Professor GAGE and Instructors.

X. 20. Mechanical Laboratory—Experimental Engineering M.E. Seniors. First term, credit three hours. Prerequisite courses X. 10, 11, P. 10. One laboratory period a week. Efficiency tests of gas and gasoline engines, steam injectors, steam turbine, blowing fan, hydraulic turbine and centrifugal pump; flue gas analysis, etc. Reports are required to be full and complete, to include data and results of each test under consideration, and all information necessary to understand completely the machine tested and the methods used. Assistant Professor GAGE and Instructors.

X. 21. Mechanical Laboratory—General Experimental Engineering. Seniors in M.E. Second term, credit three hours. One laboratory period a week alternating with one computing period. Written report required on each experiment. Detailed study of methods of testing and methods of computation in the following subjects: testing of engines and boilers, air compressors, ice machines; measurement of flow of water, etc. Reports required as in X. 20. Instructing staff as in X. 20.

X. 22. Mechanical Laboratory. Required of Seniors in the Electrical Engineering Option. First term, credit two hours. Prerequisites X. 10, 11 and P. 10. Selected experiments from Course X. 20. Instructing staff as in X. 20.

B. Engineering Research Division

X. 30. Engineering Research. Elective. Either of both terms; credit one hour for forty hours of actual work. Open to a limited number of seniors and graduates who have available at least two laboratory periods per week and who have shown proficiency in engineering subjects. Special problems and investigations which are in general carried on in the laboratories under the immediate direction of the members of this department, but which may be carried on in any department of the college under the general supervision of this department. Professors DIEDERICHS and SAWDON and Assistant Professor UPTON, and Mr. DAVIS.

X. 32. Thesis. Senior elective. Either or both terms, maximum total credit eight hours. If a thesis is elected, permission to carry on the work connected with it must be obtained before Oct. 31. The work on which the thesis is based must be original investigation. All theses are under the general supervision of the Department of Experimental Engineering. The thesis may be a theoretical investigation, a design, experimental work, or other research and may be conducted under the guidance of members of any department of the college, but subject to the general supervision of this department. All students who are considering the preparation of a thesis should consult the head of this department during the junior year if possible. A bound copy of the thesis, in the original typewriting (not a carbon copy) on paper 8 x 10½ inches in size must be deposited before May 15 at the Dean's office, with the approval of the Professor in charge of the investigation. This copy becomes the property of the University, and is filed in the General Library where it becomes accessible for reference. Professors DIEDERICHS and SAWDON and Assistant Professor UPTON and Mr. DAVIS.

X. 40. Sibley Journal Credit. Undergraduate members of the Sibley Journal Board may receive not to exceed two hours of University credit in each term of their senior year (i. e. a maximum credit of four hours) for work satisfactorily

done for The Sibley Journal, provided they are elected to the Board in their Sophomore year, or before, and continue as active members on to the end of the term in which credit is desired.

DEPARTMENT OF ELECTRICAL ENGINEERING

E. 5. Introductory Course in Electrical Engineering. Required of all sophomores. Second term only, credit two hours. Two lectures each week. Prerequisite courses Physics 3 and Math. 6. Electric and magnetic circuits; also descriptive work on electrical machinery and its applications. Assistant Professor PERTSCH.

E. 12. Essentials of Electrical Engineering. Required of seniors in the civil engineering and chemistry courses. First term only, credit four hours. Two recitations and one laboratory experiment with report each week. The purpose of the course is fourfold: (1) to review and emphasize the fundamental physical principles applied in electrical engineering; (2) to familiarize the student with and give practice in the handling of electrical machinery; (3) to enable the student to choose the proper type of apparatus for any particular service demanded in ordinary elementary practice; (4) to enable the student to read intelligently electrical engineering literature. Assistant Professor PERTSCH and Instructor.

E. 14. Elementary Electrical Engineering. Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours a term. Prerequisite courses Physics 8, 9, 14, M. 5, 6, E. 5. Must be accompanied by E. 15. One lecture and one computing period a week during both terms. A general course in direct and alternating current circuits and machinery. Professor GRAY and Instructors.

E. 15. Elementary Electrical Engineering. Required of all juniors in the regular course, and of seniors in mining. Throughout the year, credit two hours a term. Prerequisite courses Physics 8, 9 and 14, M. 5 and 6. Must be accompanied by E. 14. One recitation and one laboratory period a week during both terms. Experimental work on the subjects taken up in E. 14. Professor GRAY and Instructors.

E. 20. Theory of Electrical Machinery. Required of seniors in Option A. Throughout the year, credit two hours a term. Prerequisite courses E. 14 and 15. Two lectures a week. First term covers chiefly the laws of the electric and the magnetic circuits; representation of alternating currents by vectors and by complex quantities; the nature and effects of inductance, capacity, and iron loss; theory of transmission lines and transformers. Second term is devoted to the theory of transmission lines, transformers, generators, motors, and rotary converters. The lectures are as far as possible correlated with the work in course E. 21. Professor KARAPETOFF.

E. 21. Characteristics of Electrical Machinery. Required of seniors in Option A. Throughout the year, credit three hours a term. Prerequisite courses E. 14 and 15. Two recitations and one computing period a week. Problems on the work covered by course E. 20; in particular, performance, characteristics and elementary design of transmission lines, transformers, induction motors,

alternators, synchronous motors and converters, and direct-current generators and motors. Professor KARAPETOFF and Instructors.

E. 22. Electrical Design. Required of seniors in Option A. Throughout the year, credit two hours a term. Must be accompanied by E. 20 and E. 21. One recitation and one computing period a week. Principles of commercial design of electrical machinery, and the preparation of specifications. Professor GRAY and Assistant Professor PERTSCH.

E. 23. Central Stations. Elective for seniors in E.E. Second term only, credit two hours. One recitation and one computing period a week. Selection, maintenance, and operation of equipment, also questions of public policy and finance.

E. 25. Elements of Electric Railway Practice. Elective for seniors. Second term only, credit two hours. Prerequisite courses E. 14 and 15. One recitation and one computing period a week. Apparatus and construction involved in a modern railway system, including cars and car equipment, overhead and track construction, and other topics of similar character. Some attention is devoted to the relation of electric railways to the public and to finance. Mr. CHAMBERLAIN.

E. 27. Wireless Telegraphy and Telephony. Elective for seniors in electrical engineering. Second term only, two hours credit. Two recitations a week. Prerequisite courses first term of E. 20, E. 21, and E. 28. Fundamental principles involved in wireless telegraphy and telephony, and study of the development of the application of these principles up to the present status of the art. Assistant Professor BALLARD.

E. 28. Senior Electrical Laboratory. Required of seniors in electrical engineering (Option A). Throughout the year, credit four hours a term. Must be accompanied by E. 20 and E. 21. Two laboratory periods, one recitation and one report a week. Special and commercial tests on direct and alternating current circuits, generators, motors and other apparatus. Also work on instruments and on electrical materials in the Standardizing Laboratory. The last eight weeks of the second term are devoted to an elaborate piece of experimental work, which is carried out as a research problem. Professor GRAY, Mr. CHAMBERLAIN, and Instructors.

E. 30. Engineering Mathematics. Elective. Open to seniors and graduate students only. Throughout the year, credit two hours a term. Two recitations a week and home work. General methods by which problems are expressed in mathematical form, studied to establish a better understanding of the unity between the instruction in pure mathematics and the various engineering courses. It is aimed to prepare the student better for engineering research and for the study of advanced engineering literature. The fundamental physical and mathematical assumptions are critically reviewed, and the limitations in the results pointed out. Methods are indicated for obtaining approximate solutions, establishing empirical formulæ, and solving problems by the use of tables, charts, and mechanical devices. The course consists of problems taken in different years from mechanical, civil, and electrical engineering, involving analytical geometry and the elements of differential and integral calculus. The topic will be selected to suit the class. Professor KARAPETOFF.

E. 33. Special Electrical Engineering Problems. First or second term or both. Credit two or more hours. Open to seniors. A course to meet the needs of men who are not particularly interested in the other electives. Theoretical and experimental investigations on electrical apparatus. Each student to select his own subject, which, however, must meet with the approval of the head of the Electrical Department. Professor GRAY, and other instructors as required.

E. 36. Electrical Engineering for M. E. Seniors. Required of Sibley seniors who take options B to E, inclusive. Not to be taken simultaneously with E. 37. Two hours credit; repeated in the second term. Prerequisite courses X. 11, E. 14 and E. 15. One lecture and one computing period a week. The course is arranged for the needs of mechanical engineers, particular attention being paid to the operating features of electrical machinery, and to selection of proper electrical apparatus for power and industrial purposes.

E. 37. Electrical Engineering for M. E. Seniors. Required of Sibley seniors who take options B to E inclusive. Not to be taken simultaneously with E. 36. Two hours credit; repeated in the second term. Prerequisite courses X. 11, E. 14 and E. 15. One recitation and one laboratory period a week. A continuation of the electrical laboratory work of course E. 15.

Seminary in Electrical Engineering. For seniors and graduate students. No credit. The work that was taken up last year was on polyphase commutating machines and on industrial control. Conducted by Professors GRAY and KARAPETOFF.

[NOTE. For other electrical and illumination courses see under Physics in the Announcement of Courses in the Colleges of Arts and Sciences.]

DEPARTMENT OF INDUSTRIAL ENGINEERING

I. 12. Industrial Organization. Required of all juniors in Sibley College and not open to freshmen or sophomores. Open to juniors and seniors of other colleges. First term, credit two hours. A course of lectures on modern industrial tendencies and the principles that underlie modern methods of production. The treatment includes not only the reasons for our changed methods of production but also discussion of the principal features of such industrial factors as factory legislation, factory welfare work, and modern methods of administration. Professor KIMBALL.

I. 20. Industrial Administration. Required of all seniors in Option E. Elective for seniors pursuing other options. Two lectures a week throughout the year, credit two hours a term. Prerequisite course I. 12. A discussion of modern time-keeping and cost-finding systems, methods of planning work and of insuring production, administrative reports, time and motion study, purchasing, etc.; plant location and arrangement, heating, lighting and powering of plants. Professor KIMBALL.

I. 21. Costs, Wages, and Management. Elective for juniors and seniors in Sibley College, except those who are electing, or who expect to elect, the senior industrial group; open also to upperclassmen in other colleges. Two lectures a week, first term, credit two hours.

A discussion of the fundamental principles underlying the management of industrial works with a more detailed analysis of the elements of cost finding, wage systems, time and motion study, planning of work, etc. Professor WELLS.

I. 22. Drawing and Design. Required of all seniors in Option E. One recitation and six hours in the drawing room a week throughout the year, credit three hours a term. Prerequisite courses D. 10 and D. 16, and must be accompanied by I. 20.

The work of the first term consists of graphical constructions and their application to administrative problems; graphic planning of organization and the creation of blanks and other administrative documents. In this term each student is required to make a complete outline of the organization of some industrial enterprise either from assumed data or for some plant with which he is familiar.

The work of the second term consists largely of exercises in the location and arrangement of industrial plants from the standpoint of economic production. Each student is required to locate geographically and arrange the plant for which he has made an organization outline in the work of the first term. Professor ALBERT.

I. 23. Safety Engineering and Fire Protection. Required of, and open only to, seniors in Option E. Two lectures a week during the second term, credit two hours. Prerequisite course I. 12. A discussion of modern factory construction from the standpoint of fire protection and also of safety appliances in connection with factory equipment. Professor WELLS.

I. 40. Advanced Industrial Engineering. Open to graduates and seniors who have completed the equivalent of I. 20 and 22. Professors KIMBALL, WELLS, and ALBERT.

